MODEL RAILWAYS

HENRY GREENLY

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MODEL RAILWAYS

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Their Design, Details and Practical Construction

By

HENRY GREENLY

Assoc. Inst. Loco. Eng.
Engineer, Ravenglass and Eskdale Narrow-gauge Railway
Author of "Model Engineering," etc. etc.

With 399 Photographs, Diagrams and Working Drawings

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EDITOR'S PREFACE

"MODEL RAILWAYS: Their Design, Details and Practical Construction" is one of a series of volumes in which two other books by the same author appear, these being "Model Steam Locomotives: Their Details and Practical Construction," and "Model Electric Locomotives and Railways: Their Details and Practical Construction." The claim that this is the most complete and the most lavishly illustrated book on the subject is, I believe, well founded. A glance at the list of contents will show the wide scope of the book. It deals with everything with which the model railway enthusiast has any concern—except, of course, the locomotive, which is the subject of the separate volumes already mentioned—and there is enough practical information, working drawings, explanatory diagrams and photographs in this book to allow of the more or less skilled reader undertaking a model railway installation of almost any dimensions.

In "Model Engineering," by the same author—a book published by the same publishers, although not in the same series—some brief biographical notes on Mr. Greenly have been given. Here it may be added that for a hundred years members of his family have been connected with either the stage coach or the railway. As a boy Mr. Greenly met and cross-examined men who worked the first railways out of London. Throughout his life he has been susceptible to the glamour and fascination of railways large and small. He has himself designed very many of the better-class models manufactured both in this country

and abroad, and he has designed and built many of the best-known miniature railways in Great Britain and the Continent. There can be no gainsaying the fact that he is the ideal author of such a book as this. He has all the knowledge required, both theoretical and practical, and in addition he has an enthusiastic love for his work and an outstanding gift for explaining and delineating all its practical aspects.

In writing this book his experience years ago with the Metropolitan Railway in the locomotive and civil engineering departments has undoubtedly stood him in good stead. He wishes to make a number of acknowledgments: To Messrs. Bassett-Lowke, Ltd. (for whom he was locomotive designer for many years), who have lent many photographs of model railways and equipment; Messrs. Mills Bros., of Sheffield, the Leeds Model Co., Ltd., and many amateurs who have contributed illustrations and information which have enhanced the value of the book. The author particularly wishes to thank his daughter, Miss Elenora H. Greenly, for the trouble she has taken in the skilful preparation of a large number of the line drawings which illustrate this book.

It may be stated that the author possesses a large number of blue-print working drawings of model railways and equipment and that he can be approached through "Work," the Weekly Journal for Amateur Mechanics, edited by the Editor of the present series of volumes.

B. E. J.

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Model Railways

CHAPTER I

Types of Model Railways

For lack of suitable material the hobby did not attain so great a vogue until the commencement of the present

Fig. 1.—Mr. J. E. P. Howey and his model 15-in. gauge Pacific-type Express Engine designed by the Author

century. Previously it was difficult to get rails and other essential accessories at a price within the reach of the average potential user. Further, cheap ready-made locomotives in small gauges and which would work successfully did not exist. The gauges were not standardised.

The earliest example of a really complete system of which the author can find records was made by two Eton boys in the 'seventies.

Classes of Model Railways.—Model railways may be divided into two classes: (1) Small-gauge lines which may be installed in a room or garden with locomotives controlled from the track, or by the attentions of a following operator. (2) Larger-gauge railways with locomotives on which the

Fig. 2.—A Canadian Model Railway in No. 0 gauge

driver can ride, and which may haul one or more passengers. These railways are classed under the broad term "Garden Railways," and, generally, it may be said that unless the locomotive is built to a scale of 1 in. to the foot, it is of no use for passenger hauling.

Even in the 1-in. scale, the $4\frac{13}{16}$-in. gauge (or sometimes 5-in.) is a little too small for safe riding, although the author has ridden on such a locomotive for over a mile non-stop with a following load of two adult passengers. Therefore, the standard gauge of $7\frac{1}{4}$ in. ($1\frac{1}{2}$ in. to the foot = $\frac{1}{8}$th full size) is more often considered to be the minimum for

outdoor or garden railways. Locomotives of $3\frac{1}{2}$-in. gauge are occasionally made, but will be found too heavy and too powerful to be sent out on a track without some form of electrical or mechanical control gear operated from the side of the line.

Indoor Railways.—The smaller kind of railway is usually laid indoors, and exigencies of space, therefore, reduce the gauge to either (No. 0) $1\frac{1}{4}$-in., (No. 1) $1\frac{3}{4}$-in., or in rare instances to 2-in. (No. 2) gauge. Where the

Fig. 3.—Mr. J. S. Robinson's No. 1 gauge Indoor Line

paramount interest of owners lies in the building and working of a locomotive, the line is often a mere outdoor testing track, and the gauge chosen is either $2\frac{1}{2}$ in., $3\frac{1}{4}$ in., or $3\frac{1}{2}$ in. The first-named gauge is by far the most popular of the three. Models of modern types of express engines in this scale measure nearly 3 ft. long, and weigh anything up to 30 lbs. in working order. American types of engines, of course, make larger and heavier models. The accompanying table gives the characteristics of each gauge.

Typical Model Railways.—In Fig. 44a, page 35, a plan is given of Mr. H. L. Stevens' No. 0 gauge railway, which

TABLE I.—STANDARD GAUGES AND THEIR CHARACTERISTICS

Gauge No. 0. = $1\frac{1}{4}$ in. *Scale* 7 m/m = 1 ft. *Tonnage coeff.* 29. $\frac{1}{48}$th *full size.*	An indoor size for use where the most comprehensive model railway system is desired in a given space. Locomotives may be driven by clockwork or electricity. At present the steam engines made for this gauge are not uniformly good, but by adopting the American loading gauge working model steam locomotives may be constructed with satisfactory results. However, any No. 0 gauge model steam locomotive will require to be very well made to ensure a reasonable measure of success.
Gauge No. 1. = $1\frac{3}{4}$ in. *Scale* 10 m/m = 1 ft. *Tonnage coeff.* 13. $\frac{1}{30}$th *full size.*	The best gauge for an indoor model electric, steam or clockwork locomotive. The scale is a convenient one from a designer's point of view, every centimetre equalling one foot in the prototype. American models (working steam locomotives) in this scale make good outdoor engines and can be fired with solid fuel.
Gauge No. 2. = 2 in. *Scale* $\frac{7}{16}$ in. = 1 ft. *Tonnage coeff.* 7. $\frac{1}{27}$th *full size.*	The characteristics of models of this scale are the same as those in No. 1 gauge, but as the two scales are so nearly the same, the interest in this one-time popular standard is waning. The advantages of the No. 1 standard over this gauge are not so slight as they would at first appear, where the available space for the model line is restricted.
Gauge No. 3. (*so-called* $\frac{1}{2}$*-in. scale*) *Scale* 13·5 m/m *or* $\frac{17}{32}$ in. = 1 ft. *Tonnage coeff.* 5·41. $\frac{1}{23}$rd *full size.*	Adopted by builders of locomotives who are interested mainly in the construction and performances of the engine itself. Model $2\frac{1}{2}$-in. gauge railways are usually mere outdoor tracks, but there is no reason why all the many embellishments of a realistic model line should not be introduced so long as the construction of these accessories is such as will withstand weather or allow the more vulnerable parts to be removed and sheltered when not in use.
$3\frac{1}{4}$-in. *and* $3\frac{1}{2}$-in. *gauges.* $\frac{11}{16}$-in. *and* $\frac{3}{4}$-in. *scales*	These are gauges commonly adopted for amateur-made and exhibition models. They are rather large where engines are allowed to run uncontrolled, and too small to ride behind with comfort and safety.
$4\frac{1}{8}$-in. *gauge.* 1-in. *scale.* $\frac{1}{12}$th *full size.*	Same as above, but some successful passenger-carrying engines have been built in this size, the gauge being widened to 5 in.

TABLE I.—STANDARD GAUGES AND THEIR CHARACTERISTICS—*Continued*

$7\frac{1}{4}$-in. *gauge.* $1\frac{1}{2}$-in. *scale.* $\frac{1}{8}$th *full size.* *Tonnage coeff.* 0·228.	The most convenient of the smaller gauges for passenger carrying. Passengers riding "single file" are quite safe on this gauge. Engines can be modelled on strictly orthodox lines, with coal firing, injectors, etc. Curves of 36 ft. to 50 ft. radius are required.
$9\frac{1}{2}$-in. *gauge.* 2-in. *scale.* $\frac{1}{6}$th *full size.* *Tonnage* 0·096.	Characteristics are the same as those of the $7\frac{1}{4}$-in. gauge. Higher speeds and slightly safer travelling are obtained by using the larger gauge. The weight of a given type of locomotive is, however, doubled (1,000 lbs. against 460 lbs.), otherwise cost and labour of making the model in this gauge are about the same as the $7\frac{1}{4}$-in. gauge.
15-in. *gauge.*	This is a standard gauge for miniature railways for estate purposes and for pleasure parks. Scales $3\frac{1}{4}$ in. and $3\frac{3}{4}$ in. = 1 ft are now adopted for model locomotives on this gauge. Weight of locomotives about $\frac{1}{50}$th to $\frac{1}{30}$th of the prototype. Two passengers abreast may be seated in the carriages. The best example is the "Eskdale" Railway, Cumberland, which is open all the year round for public traffic, mails and goods. Special types of goods locomotives may be designed for this gauge.
18-in. *gauge.*	The ideal gauge for miniature railways taking $\frac{1}{3}$rd full-size locomotives. There was a 19-in. gauge line worked with model "Pacific" locomotives in operation in America at one of the Western Coast exhibitions. The coaches can be made more comfortable for the passengers and the locomotive can completely house the engine-driver. Both these problems are more difficult of solution in the 15-in. gauge. To further elucidate the attributes of the various standard model railway gauges, the accompanying photographs of typical models are introduced. Reference should also be made to the author's companion volume "Model Steam Locomotives."

Table II.—Standard Scales and Gauges.

Scale to the foot	Rail Gauge	Tonnage Coefficient (model tons per lb. weight)	Radius of Curve		Speed Av. Max	Av. Weights		British Loading Gauge	Buffer height	Buffer Centres apart	Between Tyres
			Min.	Average		Passr. loco.	Passr. train				
	Gauge		ft. in.	ft. in.	m.p.h.						
4 m/m	No. 00 ($\frac{5}{8}$ in.)	180 tons	1 9	2 0	$\frac{1}{2}$	13 oz.	2¼ oz.	37×55 m m	14½ m/m	23 m/m	13 m/m
7 m/m	No. 0 (1¼ in.)	29 ,,	2 0	3 6	1¼	3¼ lb.	6 lb.	64×95 m/m	24½ m,m	40 m/m	27½ m/m
10 m/m	No. 1 (1⅞ in.)	13 ,,	3 6	4 6	3	8¼ lb.	18 lb.	90×135 m/m	35 m/m	58 m/m	39½ m/m
11¼ m/m ($\frac{7}{16}$ in.)	No. 2 (2 in.)	7 ,,	4 0	6 0	4	14 lb.	29 lb.	99×149 m/m	38 m/m	64 m/m	44½ m/m
13.5 ($\frac{17}{32}$ in.) "Half inch"	2½ in.	5.41 ,,	5 0	8 6	5	19 lb.	40 lb.	4⅝×7¼ in.	1$\frac{13}{16}$ in.	3 in.	2$\frac{19}{32}$ in.
$\frac{11}{16}$ in.	3¼ in.	2.4 ,,	8 6	13 0	6	45 lb.	100 lb.	6¼ in.×9½ in.	2⅜ in.	3$\frac{15}{16}$ in.	3$\frac{1}{32}$ in.
¾ in.	3$\frac{1}{32}$ in.	1.82 ,,	10 0	16 0	7	60 lb.	150 lb.	6¾ in.×10½ in.	2⅝ in.	4¼ in.	3$\frac{11}{32}$ in.
1 in.	4$\frac{13}{16}$ (or 5 in.)	.775,,	15 0	25 0	9	120 lb.	300 lb.	9¼ in.×13½ in.	3½ in.	5$\frac{11}{16}$ in.	4½ in. or 4$\frac{11}{16}$
1½ in.	7¼ in.	.228,,	35 0	60 0	12	450 lb.	1200 lb.	13½in.×20¼ in.	5¼ in.	8¼ in.	7 in.
2 in.	9$\frac{9}{16}$ in.	.096,,	50 0	80 0	15	980 lb.	1½ tons	18¼ in.×26 in.	7 in.	11⅛ in.	9 in.
3 in. & 3.25 in.	15 in.	$\frac{1}{64}$th	80 0	120 0	25	33 cwt.	4½ tons	2′ 3″×3′ 6″	10⅝ in.	18 in.	14 in.
		$\frac{1}{80}$th	100 0	150 0	30	43 cwt.	8 tons	2′ 6″×3′ 11″	12 in.	20 in.	13⅞ in.

Tonnage Coefficient is the scale equivalent of the weight of a train or loco. in tons actual of the particular prototype. Multiply the weight in lb. of the model by the coefficient given and the result is scale tons.

Curves. The minimum radius should be used for sidings and slow-speed lines. For fast running use the average radius as a minimum.

Loading Gauge. The American loading gauge is the scale equivalent of 10 ft. 2 in. wide × 15 ft. high.

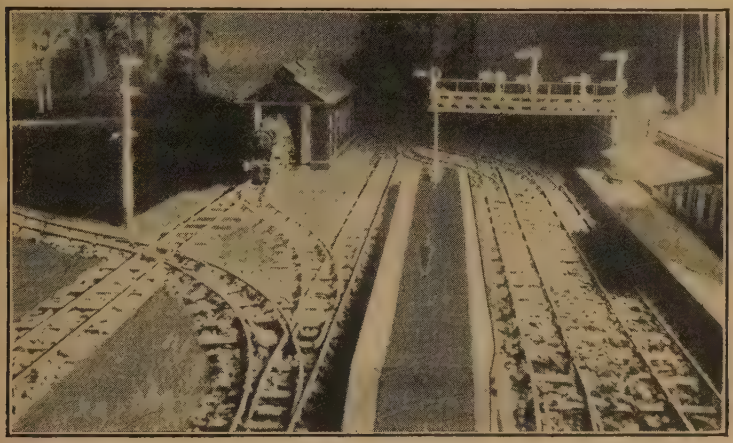


Fig. 4.—Mr. E. T. R. Ball's No. 1 gauge Model Railway

has for the past four years been under construction, and will constitute, when completed, one of the finest railways yet built in this gauge. It is laid in an attic room, and is operated electrically, there being three main sections, each governed by three or four reverser controllers, in the installation. While the comprehensiveness of the system where No. 0 gauge is used may be enormously increased, compared with the next larger standard size, No. 1 gauge, the work involved is smaller and more delicate. With amateur construction the work may be a little coarse. This may be masked by skilful attention to details, such as sleeper spacing, and the relative proportions of buildings, etc. Where scenic effects are desired, No. 0 gauge lends itself to spacious treatments, as will be seen by the photograph (Fig. 2) of a portion of a Canadian model measuring only a few feet long. Quite a long stretch of open country is represented in this small part of the model.

No. 1 Gauge.—In No. 1 gauge the work involved in

making the buildings is not so difficult. The part of a No. 1 gauge railway (see Fig. 3) built by Mr. J. S. Robinson, a Keighley amateur, is typical of many excellent indoor models made in this gauge. The next illustrations (Figs. 4 and 5) show two parts of an interesting No. 1 ($1\frac{3}{4}$in.) gauge indoor line made by Mr. E. T. R. Ball.

No. 2 Gauge.—In No. 2 (2-in.) gauge the average room does not allow for very much in the way of planning, and, therefore, a simple geometrical formation, such as the figure 8 railway built by Captain Mayne and illustrated in Fig. 6, is often employed. Plans of this kind are used where the interest centres in a single locomotive, a continuous track round which the engine may make lengthy non-stop runs being the leading feature of the railway. The scenic effects, stations, etc., are added to introduce realism.

The 2-in. Gauge.—Among other 2-in. gauge model railways of note are the pre-war exhibition models made for the east and the west coast railway groups. These were electrically operated, and shunting evolutions were performed entirely from the control cabin. The production

Fig. 5.—Mr. E. T. R. Ball's No. 1 gauge Terminus Station

Fig. 6.—Capt. Mayne's 2-in. gauge Railway

Fig. 7.—L.N.W.R. " West Coast " Electrically-operated 2-in. gauge Model

Fig. 8.—Two views of Mr. A. P. Whatley's Outdoor Line

of these models very largely assisted the development of the model electric locomotive. Fig. 7 shows the L.N.W.R. "West Coast" 2-in. gauge electrically-operated model, such as is described in the author's companion volume "Model Electric Locomotives and Railways."

Fig. 9.—A 3½-in. gauge Model G.N.R. Atlantic Engine

Fig. 10.—A 1-in. scale Model Locomotive

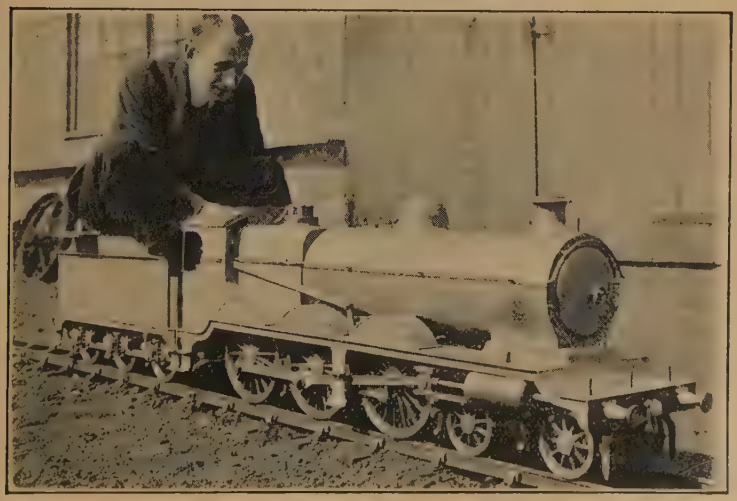


Fig. 11.—A $7\frac{1}{4}$-in. gauge Model G.C.R. Express Engine

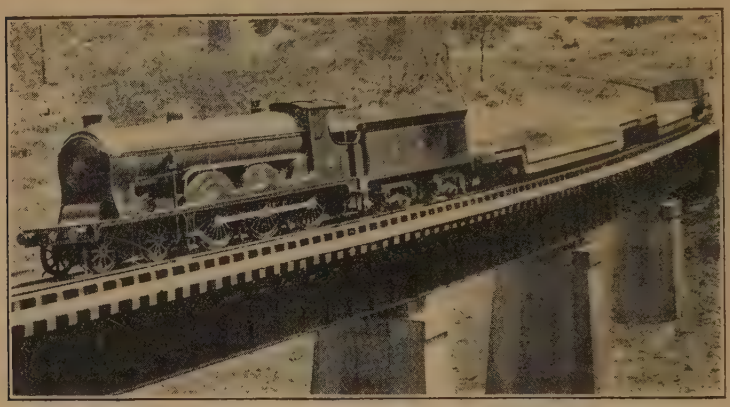


Fig. 12.—A $7\frac{1}{4}$-in. gauge Model Caledonian Express Engine

The $2\frac{1}{2}$-in. Gauge.—The $2\frac{1}{2}$-in. gauge locomotive is for the most part employed on an outdoor track, with no pretensions to realism, but there is no reason why, as shown in the photographs (Fig. 8) of Mr. A. P. Whatley's early attempt at a complete system, with suitable materials and

Fig. 13.—Mr. J. A. Holder's 2-in. scale Model Railway at Pitmaston

Fig. 14.—A 15-in. gauge Estate Line on a Fête Day

by carefully protecting all woodwork, an interesting and well-planned railway should not be built out of doors. In the worst case the stations and other buildings could be made removable, and put under cover when out of commission.

The 1-in. Scale Railways.—The 1-in. scale locomotive is illustrated in Fig. 10, with a youthful driver on board. Where such a gauge is adopted, the use of scale model stations would seem absurd. With an adult driver on the engine, whose feet may have to be accommodated on stirrups outside the vehicle on which he rides, such fitments may prove to be impossible.

Fig. 15. The Author's Pacific-type Locomotive on a Test Load

Fig. 16.—A 19-in. gauge Exhibition Railway Locomotive

Larger Gauge Railways.—Locomotives of the next larger gauges ($7\frac{1}{4}$ in. and $9\frac{1}{2}$ in.) are depicted in Figs. 11, 12 and 13. In one of them—Sir Aubrey Brocklebank's $1\frac{1}{2}$-in. scale Caledonian—the adult passengers were carried on long, low, bogie boiler-trucks.

The claims of an estate may be such as to make the construction of a quarter full-size line a paying as well as an interesting proposition. Fig. 1 on page 1 illustrates one of the largest models built in this country from the author's designs. Fig. 14 on page 13 shows an estate line of the same gauge (15 in.) on a fête day, while Fig. 15 is a load of coal being hauled by the above-mentioned

Fig. 17.—Another view of the 19-in. gauge American Locomotive (one-third full size)

"Pacific" engine on the Duke of Westminster's line at Eaton Hall.

The American 19-in. gauge exhibition railway locomotive and train is shown in Figs. 16 and 17. The driver is, in this engine, completely covered by the cab, while each of the bogie carriages comfortably carries 16 passengers. A standard train consists of 18 cars.

Fig. 18.—Photograph showing the high degree of realism obtained in a No. 0 gauge Model Railway

From the foregoing photographs and notes it will be seen that the model railway has many phases. To some amateurs the locomotive is the chief interest, to others realistic effects and carrying out of proper railway operations in miniature are accomplished. Mr. S. Gledhill's No. 0 ($1\frac{1}{4}$ in.) gauge line, illustrated in Fig. 18, is a successful example of the latter, and the trend of the information provided in this book is to satisfying those who are interested in such railway models.

CHAPTER II

Planning an Indoor Model Railway

THE average indoor railway has usually a very humble beginning. It more often than not consists of a simple "circle" of ready-made tin-plate track laid on the floor, with possibly the addition of a few straight lengths to form a long oval. Points may be introduced later, and while a goodly amount of fun can be obtained from such a line, the limitations of the tin-plate track soon make themselves felt, and the user who intends to continue the model railway hobby looks about for a suitable room in which he can install a permanent line. This question of site is, nine times out of ten, as troublesome to the model engineer as the difficulties with landowners were to the early railway pioneers.

Semi-portable Railway.—While an attic or any other spare top-room inside the house is the ideal place for a permanent model line in No. 0 or No. 1 gauge, such a room is not always obtainable and, therefore, developments from the initial portable dining-room floor scheme may take the form of a semi-portable line. In this arrangement the track is of the permanent variety and is laid down on frames in sections 6 ft. or 7 ft. long. This substructure should consist of 1-in. by 2-in. braced frames on which planed boards ($\frac{5}{8}$-in. matching) are nailed. Sleepers are fixed to the matchboarding in the usual way. The sections should not be more than 2 ft. to 2 ft. 6 in. wide, otherwise they will be inconvenient both to handle and to store when not in use. The boards on a wide track may be

placed across the narrower width, but this depends on the under-framing scheme adopted. With single or double tracks one or two boards only are necessary, and these may be strengthened and prevented from warping unduly by placing the 1-in. by 2-in. material on edge across the boards. This method is illustrated in the sketch sections, Fig. 19. All stations and other superstructures may be removable. Blocks or similar means of registering their positions may be provided on the baseboard of the track. Some accessories, like turn-tables, may have to be arranged to remain on the track when it is stored, and must be allowed for in designing the lay-out.

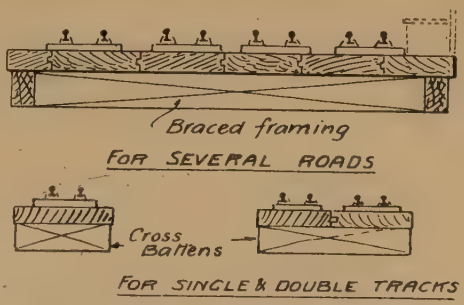


Fig. 19.—Sections showing Construction of Base-boards for Semi-portable Model

Where clock-work or electrically driven locomotives are used, the ideal plan is a non-continuous one. For one operator the scheme shown in Fig. 20 may be adopted. Such a line can be laid in a hall or an upstairs passage with an end entrance to an available room. The latter may be made use of temporarily, and arranged to contain the circular portion of the track which is necessary to effect the return of the trains to the terminal station from whence they start. Two operators may be accommodated by planning a passing station on the circular section as indicated in the sketch by dotted lines. Such a line is very easy to signal, as the roads—except at the terminus, where all kinds of movements may be made—are unidirectional. The next plan, Fig. 21, introduces two terminals, which,

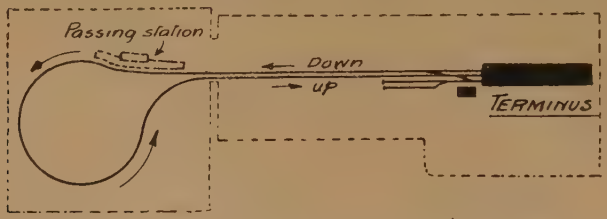


Fig. 20.—Non-continuous Plan with one Terminus

although adjacent, are entirely separate from one another, and are, in imagination, at distant ends of a long single-line track. Here the line must be signalled for trains working in both directions unless a double line is laid, when there would, of course, be four parallel roads at the neck of the plan. The sections are indicated by dotted lines across the track and the whole system involves the use of some 60 ft. of single main line, exclusive of station sidings and extra platform roads. This is a suitable distance between terminus stations in a No. 0 gauge line. A complete train can be hauled from terminus to terminus and the average good quality clockwork locomotive would still have enough power left to perform minor shunting operations, before and after arrival.

Non-continuous Plans.—The use of several locomotives on a non-continuous model railway system is the ideal arrangement where clockwork engines are employed. The

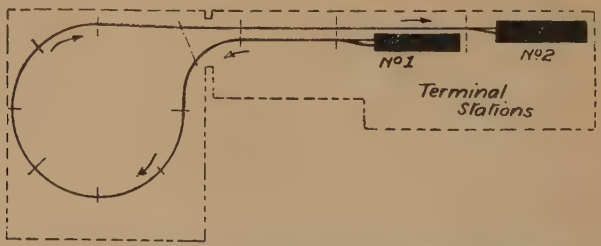


Fig. 21.—Non-continuous Plan with two Adjacent Terminal Stations

winding up is not noticed very much, and the writer, with two or three companions, has often been highly amused with such a line as those just described, working out a time-table extending over an hour or so in proper railway style. Mr. G. H. King's well-known plan was similar to that shown in Fig. 21, except that the terminals were placed against opposite walls at one end of a long room, and about four passing stations, one with a loop, were arranged between the termini.

Continuous Tracks with Terminal Stations.—Where the railway must be confined to a room, the author recommends the type of plan outlined by Fig. 22. This is a combined continuous and terminal plan, and is admirably adapted to all systems of model railway traction. A steam engine can be allowed to career around the circular line as many times as is thought desirable, and at the finish be diverted into one or other of the termini. These stations are, in the plan shown, within the circle, and, therefore, can be attended to quite easily by one operator. Fig. 23 is a detail of one of the two large terminals which may be fitted into the corner of the room. Where an L-shaped room is available for the projected railway, the plan may be modified by placing at least one of the terminal stations outside the circle. This is illustrated at A (Fig. 24). The scheme B (Fig. 24) is obtained by another slight amendment of the original arrangement. In plan (Fig. 23) the cross-over C may be placed to the left of point A. Point B may

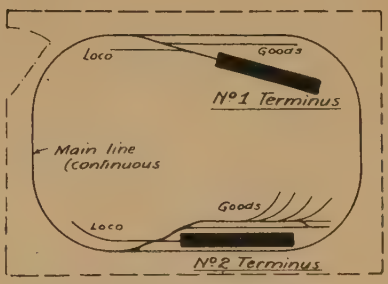


Fig. 22.—Continuous Track with Branched Terminals

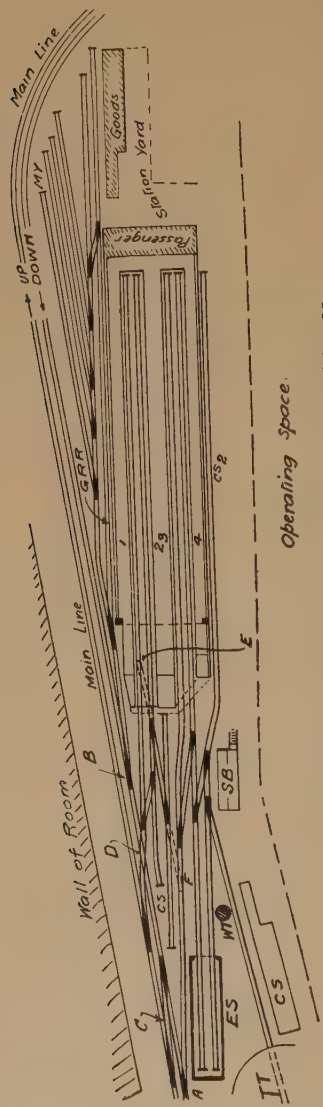


Fig. 23.—Detail Plan for a Terminus for Fig. 22

be arranged on the No. 1 terminus road instead of the main line, D being single or double slip points. The cross-overs indicated at E and F would also be useful. The road marked G R R is a goods train reception road.

Single - station Railways.—Some model railway builders may elect to concentrate the whole of their energies on one big station. In that case the principle introduced into the point-to-point plan is satisfied at the expense of a mental subterfuge in operating the model. The trains will use the various platforms (see Fig. 25) as departure, arrival or passing-through roads, as circumstances may require. Time-table working is, with such a plan, hardly possible. In any case, it would be difficult unless the main station was sufficiently large to warrant two cabins and two "model" signalmen, with an intermediate station or block section manned by a third person in the middle distance, to

separate the two station controllers on one side at least. Such an arrangement would be a very workable scheme from a railwayman's point of view.

The No. 1 gauge plan (Fig. 26) was prepared for a 14-ft. by 20-ft. room, and would, of course, suit a No. 0

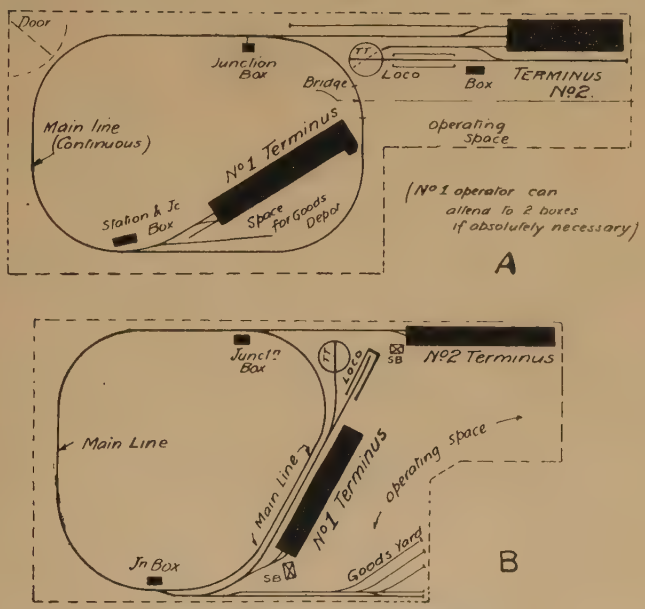


Fig. 24.—Plans for L-shaped Room

($1\frac{1}{4}$ in.) system even better than it does the $1\frac{3}{4}$-in. gauge, as the curves and length of platform would be increased in proportion to the length of a standard train. The station could, in this case, be provided with a "down side" terminal or "bay" platform, the same as branches from the up line. On the down line every crossing emerges from the straight track. This makes fast running possible

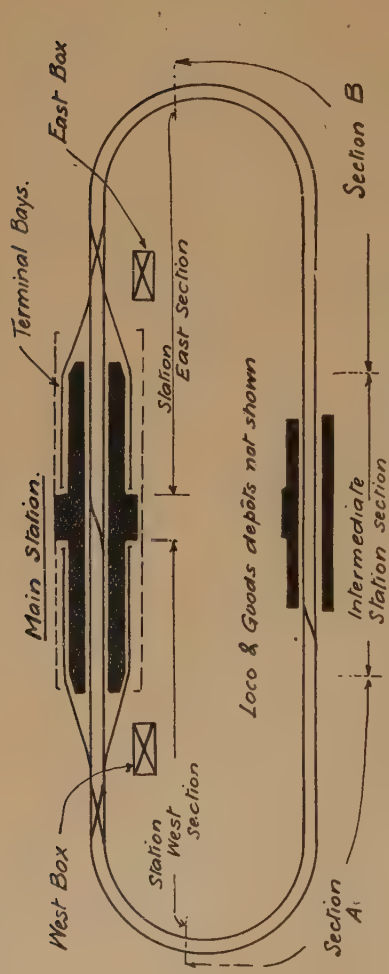


Fig. 25.—Plan for a Line with a Single Large Station

throughout the circle. On the up line the points at each end of the No. 2 station may be of a very flat angle, so that the maximum speed allowable will be very little less than that on the down. The goods roads at No. 1 are approached by backing in. This arrangement does not "trap" engines which are arriving with "pick up" or "set down" goods trains. At No. 2, arriving goods trains on the down line can run round the train to perform shunting operations in the goods yard. Possibly the entrance crossover to the goods yard would be better placed at point A (see dotted lines, Fig. 26). Fig. 27 shows a modified lay-out for this station, in which the space G, at which a goods train arriving

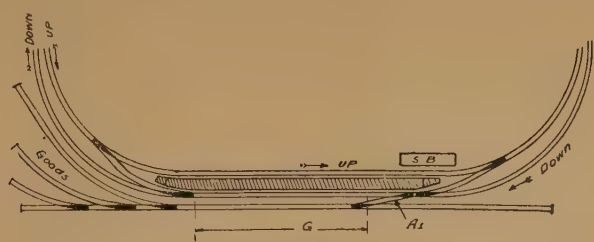


Fig. 27.—Alternative Details for Plan shown by Fig. 26

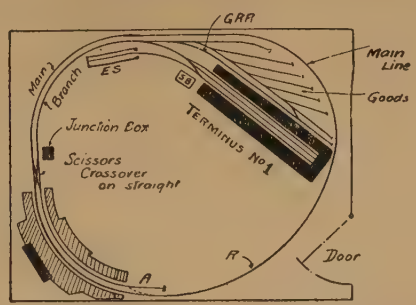


Fig. 28.—Continuous Plan with One Terminus Station

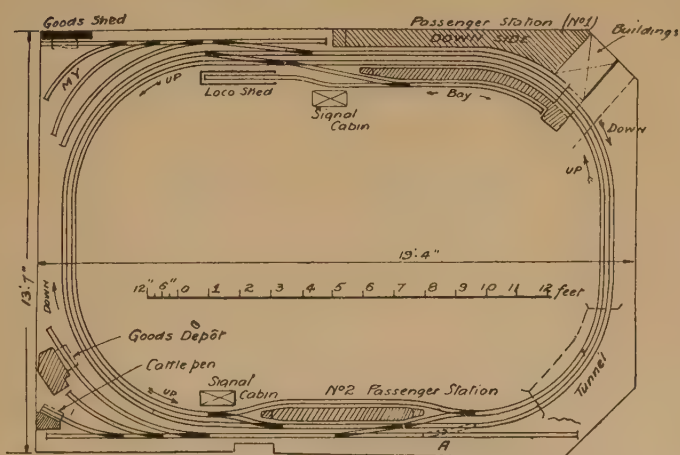


Fig. 26.—Continuous Plan in No. 1 gauge for Small Room

would be left while the engine runs round it, is lengthened. The entering crossover is also placed well to the right, as shown at A[1]. If a longer room is available these difficulties of providing sufficient accommodation for trains of average length do not present themselves. In No. 0 gauge they are still less acute. As it stands, the plan (Fig. 26) can be accommodated in a room 10 ft. wide by 15 ft. long.

The plan (Fig. 28) is a modification of diagram Fig. 22. It provides a circular track continuous for high-speed running, such as would be considered desirable where a steam locomotive is employed, and at the same time gives terminal to terminal working. The main line is single, and would be worked in both directions. The junction box is the main controlling point, and directs trains to the terminal No. 1, or to the bay road of the passing station. A crossover could, of course, be introduced on this road at A. The main goods yard is situated behind the main station (No. 1), and has a goods reception road (G R R) for arriving trains. A complete detail of a similar terminal is illustrated in Fig. 23.

Fig. 29 shows how sidings can be introduced at the subsidiary station. It will also be seen that the scissors-crossing at the junction is an essential feature of the scheme, especially where the width of the room in which the model railway is laid is restricted. The large-radius curve (R, Fig. 28) is recommended as a suitable means of clearing the entrance door to the room. Such a curve is quite as satisfactory as a combination of two straight lengths and a curve at the corner nearest the doorway. While the line is a single one, the fact that the main track and the branch to the terminus run parallel for a short distance will allow this part of the model to be treated, for scenic purposes, as a double-line railway.

Lieut. Colver's Plan.—This plan is a very ingenious one. During a discussion on the merits of various point to point plans with Lieut. Colver, it appeared that none of the usual types would satisfy him. He had worked out the scheme illustrated herewith (see Fig. 30) with a view to providing the maximum effect. A railway on these lines is an excellent one for a room of the shape shown in the plan. The train in making one complete journey did not travel over the same lines twice, and although it will pass through the intermediate station four times, it will be always travelling on the correct road and in the proper direction. The four road sections are arranged in the L.S.W.R. style, i.e. with the two fast roads in the centre, the outer lines being slow platform roads. Such stations are numerous, there being examples at Rhyl,

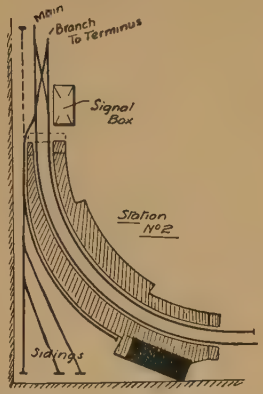


Fig. 29.—Alternative Detail of Station shown by Fig. 28

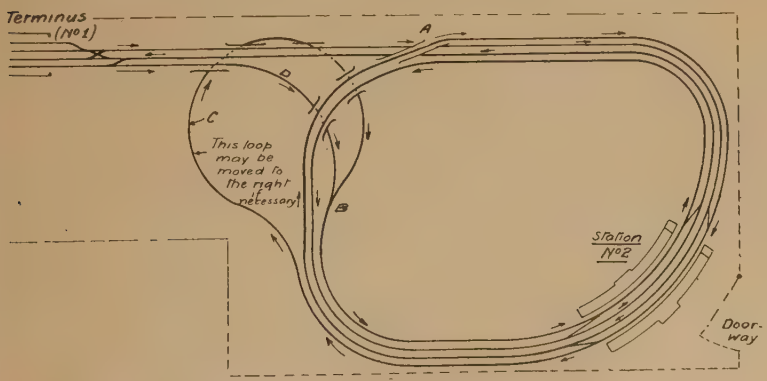


Fig. 30.—Lt. Colver's Plan for a Four-road Model Railway

North Wales, Brookwood and Farnborough, Hants. Cross-over roads are usual in such places, as illustrated in Fig. 31. The addition of these crossings at the passing station will allow continuous running, and also provide passing loops.

The use of the "flying junctions"—a feature of L.B.S.C.R. suburban lines—is introduced at A (Fig. 30). Where the space available for the railway is very limited it is essential that the No. 2 station should be placed as far away as possible from these points, so that the gradients may be reduced to the minimum. For an up-grade nothing steeper than 1 in 30 should be considered. Otherwise the crossing should be effected on the level.

Fig. 31.—The L.S.W.R. System of Four-track Railways

From the point of view of train working the exact position of the loop (C) is immaterial. It may, if the shape of the room dictates, be placed farther over to the right hand. The only thing against this is that the incline at D is steepened, but this is a down-gradient, and is therefore of lesser importance. If the junction B is brought closer to, or is at station No. 2, then the loop C may be made to pass over the other lines.

General Notes on Station Plans.—It is difficult to lay down definite laws in the science of model station planning. There are so many factors other than the exigencies of the site which govern the arrangement of junction sidings and crossovers, and every case must be treated on its merits. The chief points to observe are:—

(*a*) That crossovers should be placed so that trains can be shunted into the roads they serve. The plan (Fig. 32) is an impossible arrangement. The No. 2 road can only be entered by one vehicle at a time; (*b*) sidings should be set out so that engines of arriving trains are not trapped; (*c*) access to and egress from all parts of depot should be possible with the least amount of shunting back.

The plan (Fig. 33) is a particularly bad example of this failing; to get at the engine-house or goods shed from the

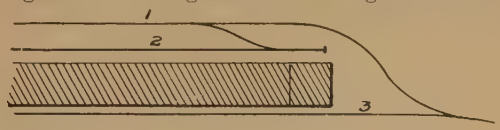


Fig. 32

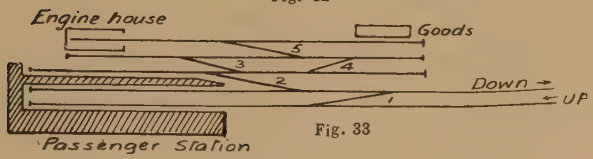


Fig. 33

Figs. 32 and 33.—How not to arrange Sidings

"up" main line means about four reversals. The shunting operations necessary in marshalling goods trains should, if possible, be quite clear of all main lines.

Typical Planning in Real Practice.—The accompanying diagrams (Figs. 34 and 35) are based on notes issued by the General Superintendent of the N.E.R. for the purpose of explaining and standardising the nomenclature of rail plans. The terms used, however, vary with different railway companies. A duplicate line is called a relief line on the G.W.R. and a slow line by other companies. The diagram will, however, prove useful as exemplifying at least one recognised scheme, and Table III elucidates the reference letters.

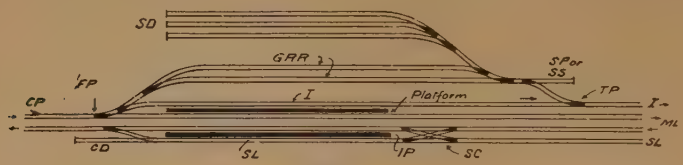


Fig. 34

Figs. 34 and 35 (*opposite*).—**Key Diagrams for Table III**

TABLE III

RAILWAY NOMENCLATURE

(*See Figs.* 34 *and* 35)

M.L. (*Main Lines*).—The principal running lines of a railway, being arranged as "up" and "down" lines, or as single lines for working trains in both directions, used by all classes of trains. M.L.B. shows the main line of a branch. The signals to such a branch may be ringed, or otherwise differentiated, at the junction, but would be ordinary main line signals afterwards.

D.P. (*Duplicate Lines*), are used where traffic is dense and are additional running lines used by all classes of traffic. Sometimes such sets of track are reserved for slower passenger and goods trains, so that the other sets can be mainly employed for express trains.

S.L. (*Slow Lines*).—Additional lines used by all classes of traffic, but not for express trains, except in an emergency. In the plan the slow line serves the station and acts as a passenger train loop. It would allow an express to pass a stopping train at this point.

The scissors crossing (S.C.) is useful in the position shown to arrange for an interchange of such traffic at the station to allow either of the platform roads to be used by fast or slow line trains. See also Fig. 36 for a use of scissors crossovers. Island platforms (I.P.) are used on this side of the station.

I (*Independent Lines*).—Lines parallel to other running lines which are through loop lines. Used for goods trains of all classes only, not by passenger trains.

F.P. (*Facing Points*) are points entered in a facing direction.

T.P. (*Trailing Points*) are points entered in a trailing direction.

R.L. (*Relief Siding*).—A siding of any desired length having a dead end used for the relief of the main line. It is usually entered by trailing points (T.P.), but sometimes by both. Protected from trains or vehicles emerging on to the main line by mistake on the part of the train men by safety points (S.P.) or a safety siding (S.S.).

G.R.R. (*Goods Reception Lines*).—A line or lines used for the reception of a goods train which may have work to do, or a line laid at the entrance of a large marshalling yard, where engines are detached and cleared.

S.P. (*Safety Points*), used to protect main lines at the junction of goods or other sidings. When the main points are normally set for the main line the points lead into the safety siding. As at S.S. a longer siding than at S.P. is used. Safety points prevent, at the trailing points of a junction, any vehicle being set back so that it fouls the junction.

S.D. (*Sidings*) for the reception or marshalling of cars or wagons.

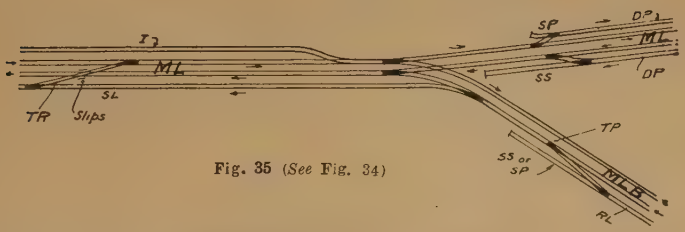


Fig. 35 (*See* Fig. 34)

C.P. (*Catch Points*).—One rail is broken in a similar manner to that in an ordinary set of trailing points. Used on steep gradients to catch run-away vehicles which may become detached from a train and go backwards. Such points are automatic.

T.R. (*Through Road*) is track crossing through one or more adjacent lines to another. Slip points may be arranged to intervene.

S.C. (*Scissors Crossing*) is equal in effect to a trailing and facing crossover and occupies the space of only one of them. In many examples a scissors crossing is placed near the centre of a long platform. It then allows one stopping train to draw in off the fast road ahead of another. See Fig. 36.

C.D.—The safety siding (S.S.) may be extended in certain places (see end of slow line at station) as a *carriage dock* for unloading horses and carriages, etc., at platform level.

Simple Terminal Plan.—In Fig. 37 a plan is shown as an improvement on the faulty one illustrated in Fig. 33. The use of a through road (TR) at a train's length from the station allows trains to leave or enter the goods loop (reception) lines 4 and 5 without interfering with the main lines Nos. 1 and 2. The platform road No. 3 is an additional station track. The engine-house can be reached in two ways, but at least an engine's length should intervene between the shed doors and the crossover to No. 3 line. Slips (S) would be useful on the through road (TR). The marshalling sidings, Nos. 6 to 9, can be worked from road No. 4. The plan at any point is not more than five roads wide, and, therefore, all parts are get-at-able from the operating space in front.

Of course, three ordinary crossovers may be substituted for the through road and slips. These will, however, occupy a greater length, and are not as useful as a through

road with a double slip at the crossing of the "down" main line.

Larger Station Plans.—The possibilities of this subject are legion. One idea, however, presents itself as important. The interior portion of a room containing a circular plan is not often wholly utilised, and to make a large model passenger station readily accessible, it is suggested that the

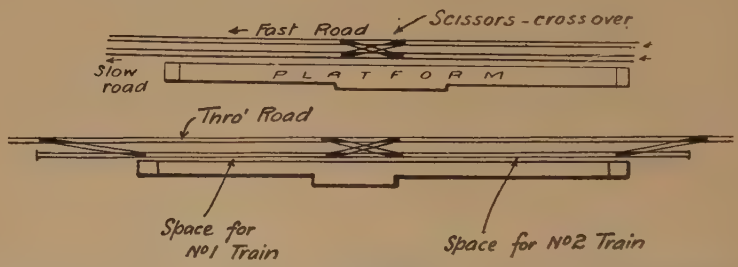


Fig. 36.—Scissors Crossover at Long Platform Road for accommodating Two Trains

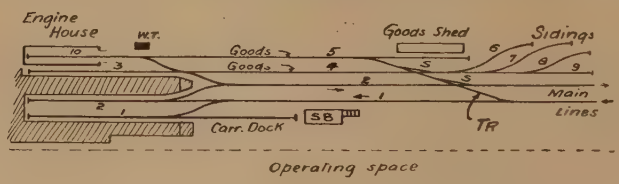


Fig. 37.—Plan for Small Terminal Station

goods and locomotive departments should be laid on a site jutting out nearly at right-angles to the main line of railway. The complete lay-out of the line is indicated in the block plan (Fig. 38), but only station No. 1 is under consideration at the moment. The railway controller can easily obtain access to all portions of the line for coupling up vehicles, etc. All features of the lay-out are sufficiently railway-like to satisfy the average critic. If it is necessary

to turn engines, a turntable or a triangular junction may be introduced at X. This arrangement of goods and locomotive lines might well be adopted in the case illustrated by Fig. 25, where only one large station is provided in the whole system, its control being divided between two station-masters. The portion jutting out could separate them, and also provide work for a third operator, if such a circumstance should require to be met.

The station plan (Fig. 39) is based on the lay-out suggested by Mr. F. W. Chubb, of the G.W.R. The plan was intended for a combined indoor and outdoor line, the latter

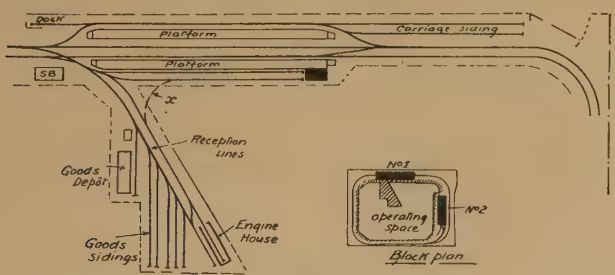


Fig. 38.—A Larger Station Plan

portion being a mere track of a continuous form. All the appliances of the line were to be under cover. The author has slightly modified it, to provide larger operating spaces. Entrances are made at C and D, and as the spaces A and B in building are less frequently employed, access to these would be made by getting under the trestles supporting the narrower parts of the track at these points.

The passenger terminus station includes two through roads and two sets of terminal lines, with a carriage dock. The goods yard and depot is approached by two long goods-train reception roads (G R R). Ample siding room is provided, all of which is accessible. Possibly two signal

boxes, one at each of the passenger stations, operated by signalmen in spaces C and D, would be found the most convenient arrangement of control.

The sketches (Fig. 40) illustrate station plans specially designed to introduce the "acute-angle crossings" of ready-made tinplate track in No. 0 gauge. They can be applied as in sketch X to a direct crossing of one line over another, from A to B at a station, by arranging a parallel portion of

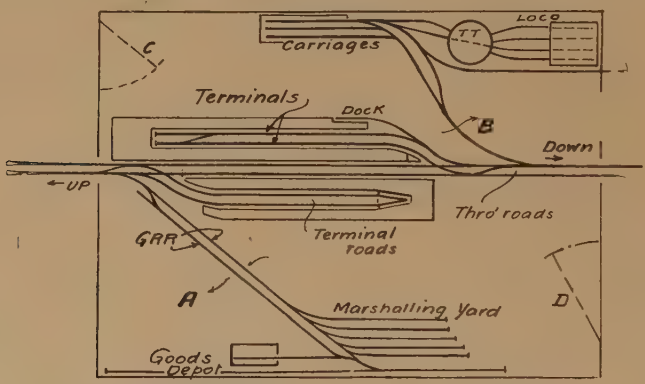


Fig. 39.—F. W. Chubb's Prize Plan for a Model Station

an island platform to serve the two roads. A siding can, if desired, be fitted up at C.

Where a double main line is necessary, and the branch is arranged to leave from the departure side, the "acute-angle crossing" can be fitted up in the arrival road to lead branch trains to a third road on the arrival side. A run-round loop may be laid down at D to facilitate disposal of arrival trains. In real practice, or in models which are laid with proper permanent way, the diamond crossings would be better if provided with slip points.

Undulating Schemes.—Where the line is operated by clockwork locomotives it is almost essential that the surface

of the track should be quite level and in one plane. The same applies to railways using steam locomotives, but to a lesser degree. The steam locomotive is likely to reach dangerous speeds on a down grade, and the absence of a driver on board the locomotive is a serious drawback. Electric locomotives controlled from the signal cabin are the most satisfactory for undulating systems and gradients as steep as 1 in 30 are practicable.

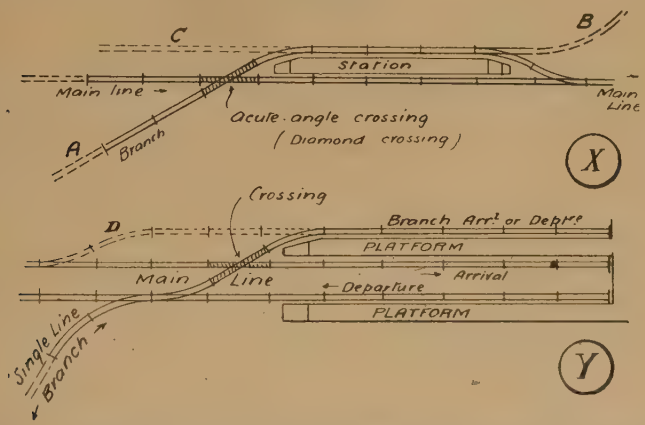


Fig. 40. Station Plan introducing Standard Model Diamond Crossover

Interest and picturesqueness may be given to a line by arranging an undulating ground surface, keeping the railway level and by skilful building up the substructure of the line to obtain this change in surface, bridges, tunnels, cuttings, embankments, culverts, etc., may be introduced at convenient intervals, as between the stations and other depots which have to be fitted up on an open space and easily accessible from the operating spaces.

Except as forming part of the scenic models installed at various exhibitions, the author has not yet seen a perfect model railway. His idea in this respect is a model railway

Fig. 41.—Mr. J. H. Ross's Model Railway with an Undulating Ground Surface

system laid round the walls of a room, with a pictorial background and a well-modelled track and foreground, the operator and visitors being placed in the centre of the panorama. The beginning and the end of the painted scenery would be cut off from the spectator's vision, and the model would be so lighted that it would give absolute realism to the view. Naturally a fairly large room would

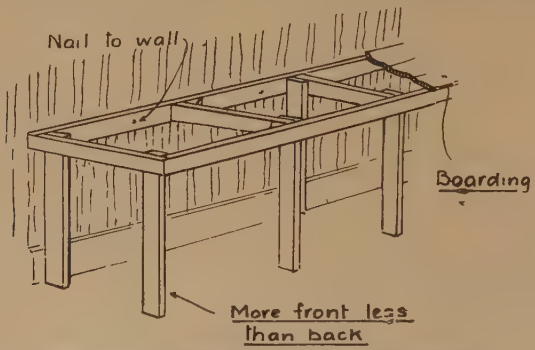


Fig. 42.—Framing for Indoor Model Railway

be required, and a wider foreground than is usually provided.

Fig. 41 is a photograph of an interesting indoor railway with an undulating ground surface, made by Mr. J. H. Ross, of Worcester. The main line of the railway is, however, quite level.

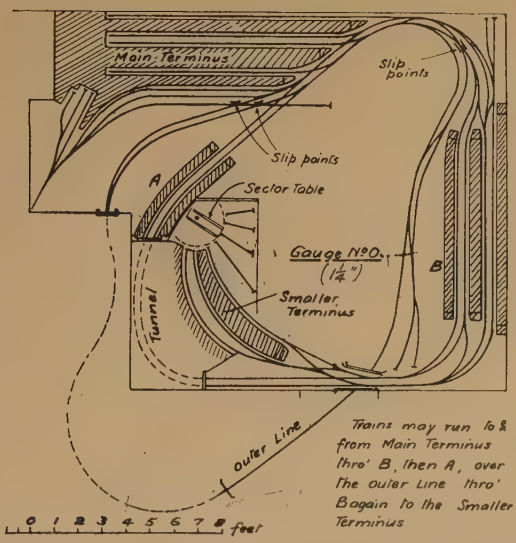


Fig 44a.—Plan of Mr. H. L. Stevens' Model No. 0 Gauge Railway

This is referred to on pages 3 and 7. The layout includes an outer line which passes under the Inner Double-main Line of Railway. The Stations provide for both Continuous and Terminal to Terminal Working.

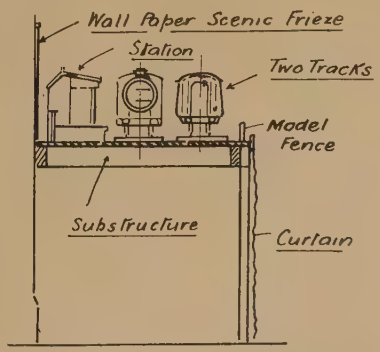


Fig. 43.—Cross Section of Indoor Model Railway

Substructures.— As a general rule, the convenient height above floor level for an indoor model railway is 3 ft. 2 in. to rail level. The line is laid on frames supported from the wall and posts to the floor. The frames are boarded. While the height of the trestling may be varied, it is, perhaps, more convenient to arrange it at one level, except at dips in the surface, which may require to be bridged by embankments or viaducts. Cuttings, tunnels, etc., are then built up from this level. Fig. 42 shows a suitable arrangement of framing. Fig. 43 is a cross-section indicating a scenic frieze or painting on the wall at the back and a curtain to mask the legs of the sub-framing in the front.

CHAPTER III

Outdoor Model Railway Planning

Small Gauge Lines. — For railways which carry small locomotives, uncontrolled as in the case of steam engines, or electric engines operated from a cabin, the tracks will have to be planned to suit the conditions of the site. If the latter is perfectly level it is usual to raise the line about 3 ft.

Fig. 44.—Mr. A. S. Thomas's 2-in. gauge Outdoor Line

above ground level on posts [see the photograph of Mr. A. S. Thomas's (New Zealand) line, Fig. 44] or on trestles. Scenic effects are difficult in such cases, but portions, at least, of the surface can be built, after the fashion of a rock garden, to carry the track.

In any case, it is advisable to have a part of the line above ground level, as attending to a locomotive on a railway laid on a level site would necessitate pits or their equivalent. One idea for masking the post or trestle substructure is illustrated in Fig. 45. The ground below the

line would be planted with privet bushes (box trees would be better, but they are slow in growth), as shown, and when fully grown the tops could be trimmed to surface level. Here and there a few stems could be left standing, as model trees or complete plantations.

The track itself is best laid on open framework—boards for the top surface are unsuitable, as they crack and warp—the sleepers crossing from member to member. The scantlings of the frame should be arranged on edge, to give greater vertical strength, and to offer less surface to the accumulation of rain water. The line may be ballasted by nailing on a basket of galvanised wire netting, finishing at the side with a strip or curb of wood. The whole structure should be coated with tar or one of the patented wood preservatives. Fig. 46 shows an enlarged section of the complete single-line track, with the privet hedge trimmed off flush.

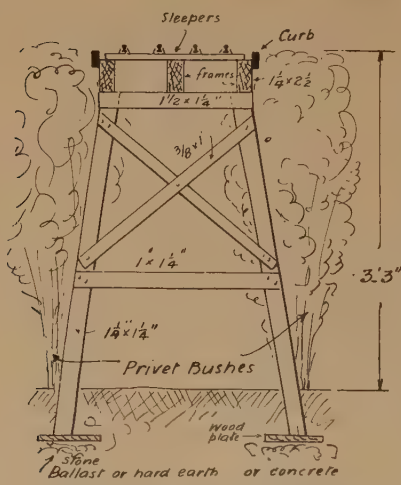


Fig. 45.—Masking Trestle Structure of Outdoor Line with Privet Hedge

Combined Indoor and Outdoor Plan.—This method of dealing with lines which are too big to be entirely housed has already been commented upon, and plans suggested. Fig. 47 is a typical case. For steam engine working a continuous track out of doors is necessary. This may be of the rectangular form or truly circular. Usually it involves a triangular junction. These are the only mechanical

appliances that are out of doors. The terminal station and all its attendant complications may be fitted up inside a conservatory or other suitable room in the house. If a non-continuous plan is most suitable, the main line would then

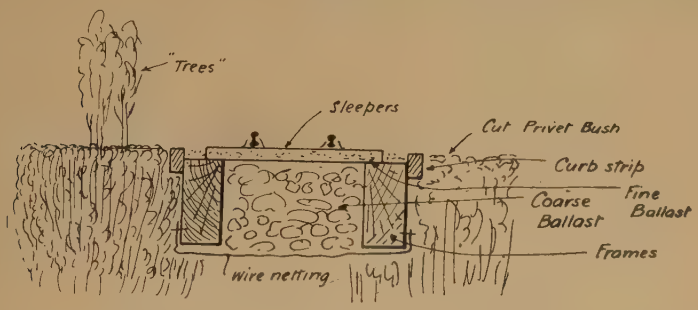


Fig. 46.—Another Masked Structure

return to the terminus, as shown by the dotted line, no points or crossings being employed outside the house. The characteristics of this type of plan are discussed in the previous chapter.

Circular Garden Railway.—For a garden line using, say, $2\frac{1}{2}$-in or 2-in gauge steam locomotives, the truly circular type of plan, recommended by Mr. A. P. Whatley, has great

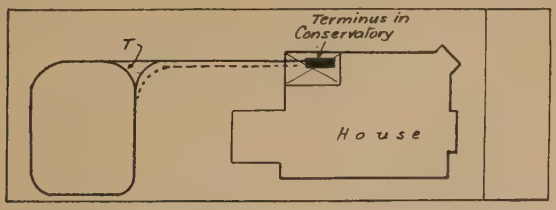


Fig. 47.—Combined Indoor and Outdoor Model Railway

merits, on a sloping site especially (see Fig. 48). No limits to speed of the trains need be imposed if the radius of the circle adopted is adequate. With the sloping site one part of the line could be tunnelled, while the other portions

would be on the level, in cuttings, or run over embankments or hedges. The place where the ground is lowest should be chosen for the site of the station, as trains can then be attended to with ease.

The accompanying plan is based on Mr. Whatley's own line, and is, under many circumstances, much to be preferred to the common rectangular arrangement with rounded corners of comparatively small radii. Such plans allow the line to be crossed at the tunnels. For the latter work large earthenware drain-pipes are suggested. Cement and concrete should also be employed lavishly in the construction of the line. As a part of the substructure this material is the only satisfactory preventative of weeds growing up between the rails. If ballast only is employed, sooner or later the line will become very untidy.

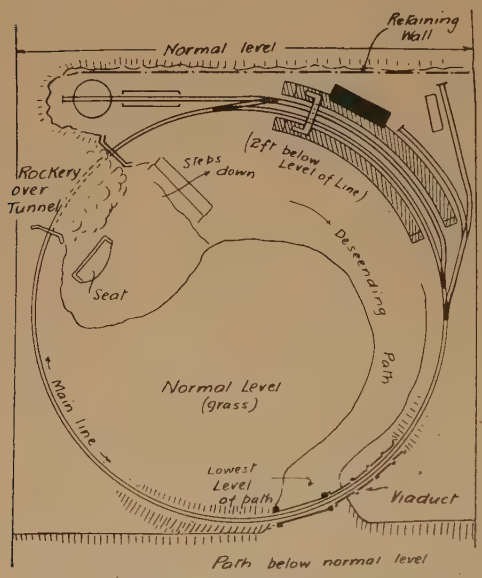


Fig. 48.—Mr. A. P. Whatley's Circular Plan for Outdoor Line

Passenger-carrying Garden Railways.—For lines of this kind careful surveying is required. If available a telescopic level (dumpy level) is a valuable asset to the work. Quite a large model railway survey can be accurately

plotted on paper in a day. The disposition of the railway having been determined, a profile should be set out to a suitable scale, the vertical dimensions, of course, being

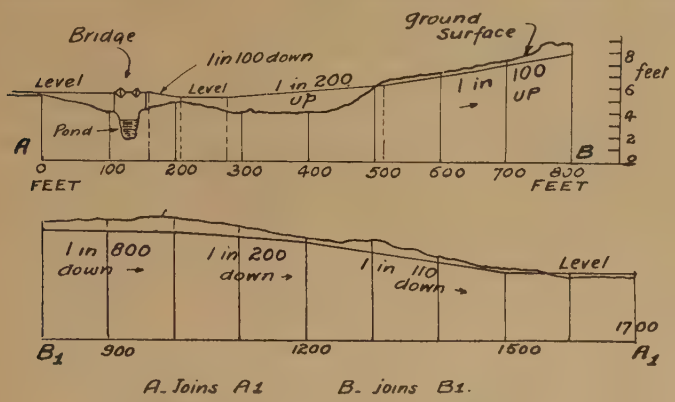


Fig. 49.—Typical Profile Plan for Large Outdoor Railway

larger than the longitudinal measurements. A typical gradient plan is shown in Fig. 49. When the profile of the ground is drawn in, the line of railway may be plotted over

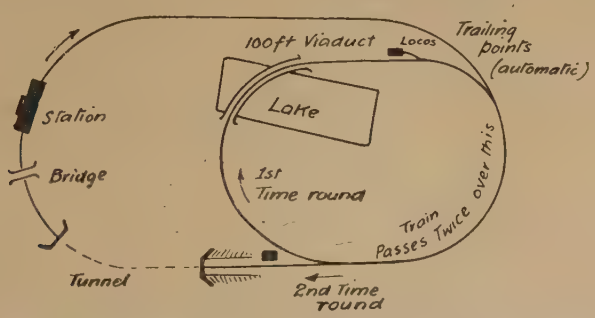


Fig. 50.—Plan of 15-in. gauge Line Designed and Built by the Author at Geneva

it with an eye to equalising the amount of earth required to be excavated with that required for embankments. Deep gorges may have to be bridged. The line of the railway

Fig. 51.—Overbridge and Tunnel, Geneva

Fig. 52.—Rhyl Station

Figs. 51 and 52. Views of the Geneva and Rhyl 15-in. gauge Railways

would, of course, be pegged out before the levels are taken. The pegs would be numbered or otherwise marked, so that they can be identified on the plan, and in choosing the places to commence work the necessary carrying of earth from the cuttings to the embankments will require to be

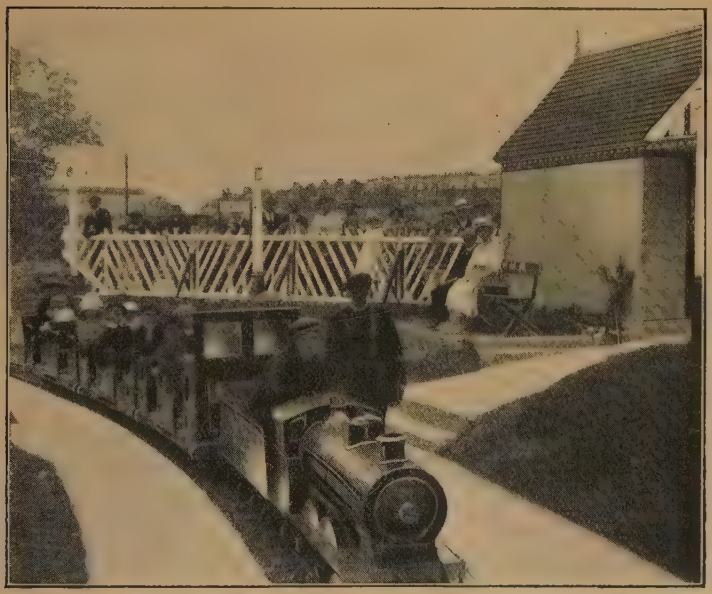


Fig. 53.—The Station on the Margate 15 in. gauge Railway

considered. The carting of the materials is another item which has to be considered.

In the particular railway illustrated by the plan, the dip in the land shown crossed by a bridge (see Chapter VIII. for photographs of finished model Forth Bridge) was an artificial depression. Good gravel, for ballast, was found at a point crossed by the line. A pit was dug for it, and instead of filling up the hole, it was bridged and flooded.

A Plan in Restricted Space.—For a pleasure park on the Continent an interesting half-mile line was laid, as shown in Fig. 50. The undulating surface did not allow of any other site. A lengthy run was obtained by passing round the inner loop over a 100 ft. viaduct and back to the station. Views of this and other similar railways are included in Figs. 51 to 53. The girder bridge indicated on the plan is shown by the photograph on p. 247.

CHAPTER IV

The Rail and Wheel Tyre : Points and Crossings

Railway Vehicles on Curves.—The author is often asked to give an opinion on the curve-negotiating qualities of some particular model locomotive or railway vehicle. Just as often he has to put a counter-question to find out whether it is a matter of the maximum safe speed of the train around a given curve, or if it is desired to know the minimum radius the vehicle will actually traverse. There is an important difference in the two phases of the problem, and it is obvious that the safe speed of a vehicle running round a curve of minimum radius will be very low indeed. In the first case, the inertia of the train, i.e. its tendency to travel in a straight line, and the amount of super-elevation required to counteract the overturning moment due to centrifugal force, must both be considered. The other part of the question involves only the relative flexibility (or rigidity) of the wheel base of the vehicles composing the train. To deal with the latter first, it is true that no railway truck or locomotive traverses a curve in a perfectly mechanical manner. The motor-car, with its Ackerman steering rigging, loose front wheels, and differential gear on the driving axle, is a much more scientific piece of apparatus. The radii adopted for the curves of full-size railways are, however, not so small as those which a road vehicle must be able to negotiate. Therefore, railway wheels are invariably fixed to their axles, and, on a curve, although the outer rail makes a longer path than the inner one, the wheels revolve at equal velocities. One or other of the wheels,

therefore, must slip on the rails. In practice the trouble is, to some extent, mitigated by coning the treads of the wheel-tyres, as shown in Fig. 54. The angle varies slightly, but an inclination of 1 in 20 is the average standard

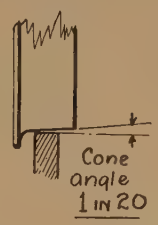


Fig. 54.—The Coning of Railway Wheel-treads

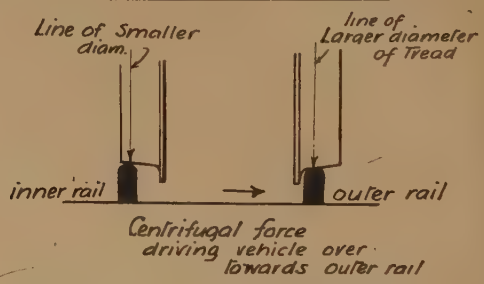


Fig. 55.—The Action of the Coning on a Curve

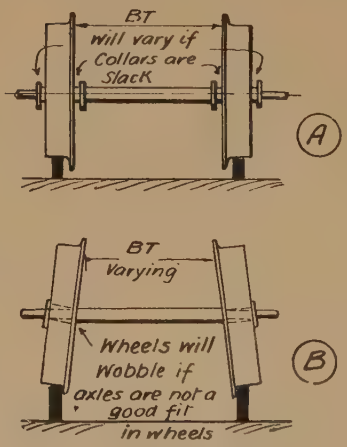


Fig. 56.—The Faults of Wheels Loose on Axles

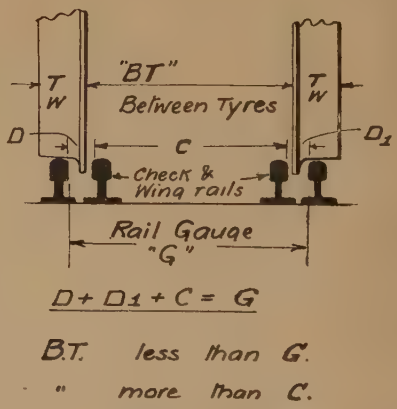


Fig. 57.—Standard Dimensions for Rails and Tyres

cone. The effect of this is to decrease the diameter of the inner wheel, while the outer wheel, which is naturally trying to run off at a tangent to the curve, has its flange pressed up hard to the rail, and is, therefore, travelling on

TABLE IV.—STANDARD RAIL AND WHEEL DIMENSIONS

(*See Figs.* 57, 86, 87 and 88)

Reference to Fig.	*G*	*BT*	*W*	*T*	*D*	*BC*	*OC*	*BTG*	*TS*	*CT*
Qualification	+		+	+	+	+	−	−	+	+
Gauge No. 0 (*Special* 7 m/m *Scale models*)	$1\frac{1}{4}$ in. 32 m/m	$1\frac{1}{8}$ 28·5 28·75	$\frac{13}{64}$ 5·5	$\frac{1}{32}$ ·75	$\frac{5}{64}$ 2	$\frac{7}{64}$ 2·5	$1\frac{3}{64}$ 27	$1\frac{1}{32}$ 26	$\frac{15}{64}$ 6	$\frac{7}{64}$ 2·5
Gauge No. 0 (*Ordinary* 7 m/m *Scale*)	$1\frac{1}{4}$ in. 32 m/m	$1\frac{1}{16}$ 27 27·5	$\frac{9}{32}$ 6·5	$\frac{1}{32}$ ·75	$\frac{7}{64}$ 2·5 3·0	$\frac{1}{8}$ 3·25	1 25·5	$\frac{63}{64}$ 25	$\frac{19}{64}$ 7	$\frac{1}{8}$ 3·25
Gauge No. 1 (10 m/m *Scale*)	$1\frac{3}{4}$ in. 45 m/m	$1\frac{17}{32}$ 39·5 40·0	$\frac{19}{64}$ 7	$\frac{1}{32}$ ·75	$\frac{7}{64}$ 2·5 3·0	$\frac{9}{64}$ 3·5	$1\frac{29}{64}$ 38	$1\frac{13}{32}$ 37·5	$\frac{19}{64}$ 7·5	$\frac{9}{64}$ 3·5
Gauge No. 2 ($\frac{7}{16}$in.*Scale*)$11\frac{1}{4}$m/m	2 in. 51 m/m	$1\frac{25}{32}$ 45·5	$\frac{19}{64}$ 7·5	$\frac{1}{32}$ ·75	$\frac{7}{64}$ 3	$\frac{9}{64}$ 3·5	$1\frac{23}{64}$ 44	$1\frac{11}{16}$ 43·5	$\frac{19}{64}$ 7·5	$\frac{9}{64}$ 3·5
Gauge No. 3 ($\frac{17}{32}$ in. *Scale*) 13·5 m/m	$2\frac{1}{2}$ in. 64·5 m/m	$2\frac{9}{32}$ 58·0 57·5	$\frac{5}{16}$ 8	$\frac{3}{64}$ 1	$\frac{1}{8}$ 3·2	$\frac{6}{32}$ 4	$2\frac{7}{32}$ 56·5	$2\frac{13}{64}$ 56	$\frac{5}{16}$ 8·5	$\frac{5}{32}$ 4
$\frac{11}{16}$ in. *Scale*	$3\frac{1}{4}$ in.	$3\frac{1}{32}$	$\frac{3}{8}$	$\frac{1}{20}$	$\frac{9}{64}$	$\frac{5}{32}$	$2\frac{15}{16}$	$2\frac{29}{32}$	$\frac{11}{32}$	$\frac{5}{32}$
$\frac{3}{4}$ in. *Scale* ($3\frac{1}{2}$ in. *Gauge*)	$3\frac{17}{32}$ in.	$3\frac{9}{32}$	$\frac{13}{32}$	$\frac{1}{20}$	$\frac{9}{64}$	$\frac{5}{32}$	$3\frac{7}{32}$	$3\frac{3}{16}$	$\frac{11}{32}$	$\frac{5}{32}$
1 in. *Scale* ($4\frac{3}{4}$ in. *Gauge*)	$4\frac{13}{16}$ in.	$4\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{64}$	$\frac{5}{32}$	$\frac{3}{16}$	$4\frac{7}{16}$	$4\frac{13}{32}$	$\frac{13}{32}$	$\frac{3}{16}$
$1\frac{1}{4}$ in. *Scale*	$6\frac{1}{4}$ in.	$5\frac{7}{8}$	$\frac{13}{16}$	$\frac{1}{8}$	$\frac{11}{64}$	$\frac{1}{4}$	$5\frac{3}{4}$	$5\frac{11}{16}$	$\frac{9}{16}$	$\frac{1}{4}$
$1\frac{1}{2}$ in. *Scale*	$7\frac{1}{4}$ in.	$6\frac{3}{4}$	$\frac{13}{16}$	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{9}{32}$	$6\frac{11}{16}$	$6\frac{5}{8}$	$\frac{5}{8}$	$\frac{9}{32}$
2 in. *Scale*	$9\frac{1}{2}$ in.	9	$1\frac{1}{16}$	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{5}{16}$	$8\frac{7}{8}$	$8\frac{13}{16}$	$\frac{11}{16}$	$\frac{5}{16}$

N.B.—In small gauge models the metric dimensions are the basis of all calculations, the English equivalent being the nearest figure in $\frac{1}{64}$th in. The qualification mark indicates whether any error in workmanship should fall on the side of an increase or decrease of the given dimension. Sign + means that dimension may be exceeded but must not be less than stated.

its largest diameter, as shown in the diagram, Fig. 55. This helps things out a little, and reduces the wear and tear of both tyres and rails.

For first-class model work, the late Mr. Henry Lea, M.I.C.E., advocated, many years ago, the use of carrying wheels running loose on their axles. If well done this is a refinement of value. In the cheapest examples of model railway toys loose wheels are invariably fitted to wagons, tenders and carriages, but as the quality of the workmanship is, for the obvious reason of the low cost, not always good, loose wheels are sometimes unsatisfactory. With badly fitting axles and ill-spaced collars the wheels can tilt and vary the all-important "between tyre" dimension, as illustrated in Fig. 56 at A and B.

To obtain satisfaction in model railway work, especially in scale models where the proper "frogs," wing, and check rails are used at points and crossings, derailments are only reduced to a minimum by the adherence to fixed standard dimensions in each gauge. Various tables are included in this book giving these particulars. (See also Fig. 57.)

Minimum Curves.—In determining the minimum curve a given vehicle will negotiate it is as well to get down to fundamental principles. It is also necessary to agree that if it were not for the clearance between the rail and the wheel flange (see Fig. 58) the ordinary vehicle would not go round a curve at all. In effect, the length of the longest wheel base, with a given minimum radius of curve, settles the amount of clearance required. In practice this axiomatic statement is applied the other way round. The lateral clearance is generally a fixed quantity. Therefore the length of rigid wheel base is limited by the clearance, as will be observed by a study of Fig. 59. The edge of the flange Z (Fig. 59) is the critical point.

The Rail and Wheel Tyre

Without some modification a six-wheeled vehicle of the same overall wheel base as a four-wheeler will not negotiate so sharp a curve. Hence the few examples of six-wheeled trucks and carriages to be found on model railways. If a six-wheeler is used it is advisable to allow the centre axle to slide sideways. This lateral movement is indicated in dotted lines in the plan view of wheels and rails, Fig. 60.

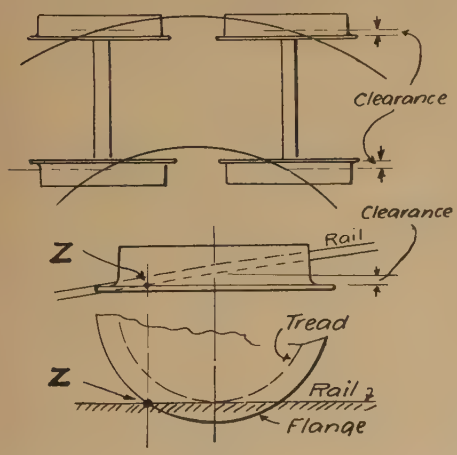


Fig. 59

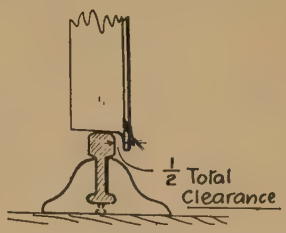


Fig. 58

Fig. 58.—Clearance Between Flange and Rail

Fig. 59.—A Rigid Railway Vehicle on a Curve

Minimum Curve of Six-wheeler.—The minimum curve of a six-wheeler may be calculated as follows:

$$R = \frac{\frac{1}{2}W \times \frac{1}{2}W}{C + G + M} = \frac{\frac{1}{4}W^2}{C + G + M}$$

Where R = Radius of curve in inches.
,, W = Wheel base in inches.
,, C = Clearance between rail and wheels.
,, G = Extra gauge allowed on curves.
,, M = Lateral play in centre axle.

In a locomotive with a partly rigid wheel base the bogie wheels should be drawn in the position of maximum lateral travel, as shown in Fig. 61. The bogie wheels should be

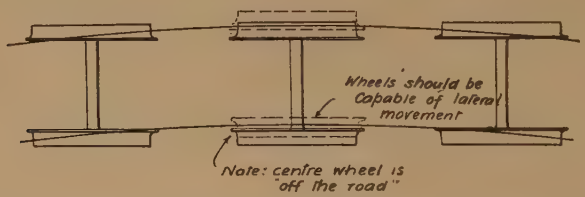


Fig. 60.—Diagram showing necessity for Side-play in Centre Axle of Six-wheeled Vehicle

in a line meeting a line drawn next the flanges of the rigid wheels at about the centre of the wheel base. The minimum curve will then be approximately:

$$R = \frac{\frac{1}{2}W \times \frac{1}{2}W}{S} = \frac{W^2}{4S}$$

If extra rail and gauge clearances are allowed on curves

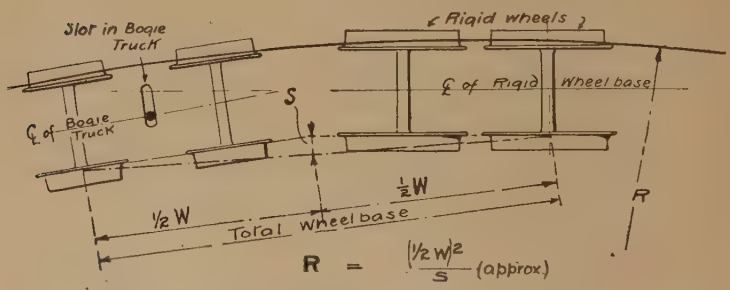


Fig. 61.—A 4-4-0 Type Locomotive on a Curve

it will ease the engine to an extent which may be arrived at arithmetically by adding the factors to S.

A double bogie vehicle is, undoubtedly, the best curve

negotiator. There must, however, be no other wheels fixed rigidly to the body of the vehicle. So long as the bogie itself, viewed as an independent vehicle, will traverse the curve, and so long as the bogie is perfectly free to rotate on its pivot pins, there is no limit to the total wheel base of the vehicle. The chief thing against overdoing it, either in the length of the vehicle or in the sharpness of the curve, is the consequent large overhang of the body of the car over the curve at the ends and in the centre, and the acuteness of the angle the end of the body will make with that of the adjacent car, as shown in Fig. 62.

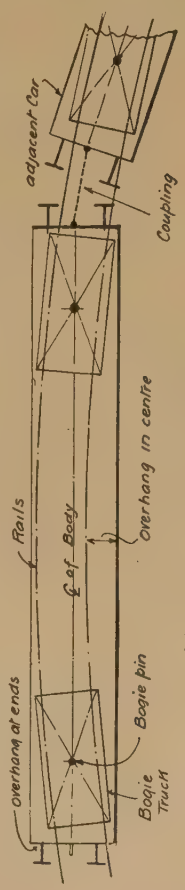


Fig. 62.—A Bogie Carriage on a Curve

A double bogie coach is quite stable when on a straight track, and needs no bogie side or swivelling control devices. The need for controlling devices in some forms of locomotives with bogies has already been commented on in the companion book to this, "Model Steam Locomotives." The diagram (Fig. 63) shows a model locomotive with no lateral stability, due to its having no rigid wheel base. A 4-4-2 type (Atlantic) locomotive with a very short coupled-wheel base, if it is fitted with a radial or pony truck for the trailing carrying wheel will suffer similarly, but not to the same extent.

Another device which has been much used for six-wheeled coaches and can be applied to models, is the Clemenson's truck (Fig. 64). The leading and trailing wheels are

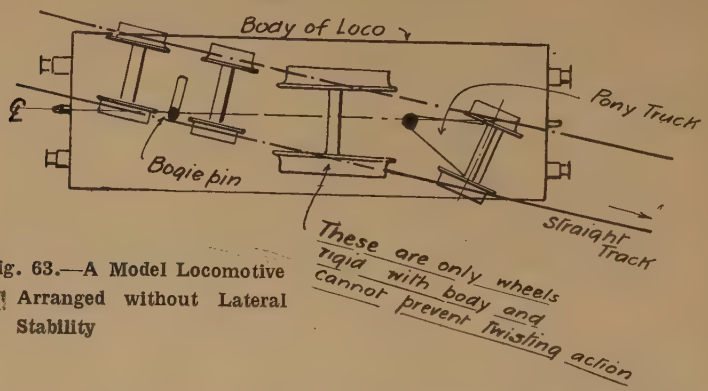


Fig. 63.—A Model Locomotive Arranged without Lateral Stability

pivoted, while the central one slides and controls the angle of the two single-wheel bogie trucks.

Action of Vehicles on Curves.—The action, on a curve, of vehicles such as locomotives which have a partly rigid and a partly flexible arrangement of wheels is complex. It is best studied by means of a diagram. The lateral stability (by which the writer means the resistance to a crab-like movement—vibratory from side to side—of the vehicle along the track) is largely dependent on the

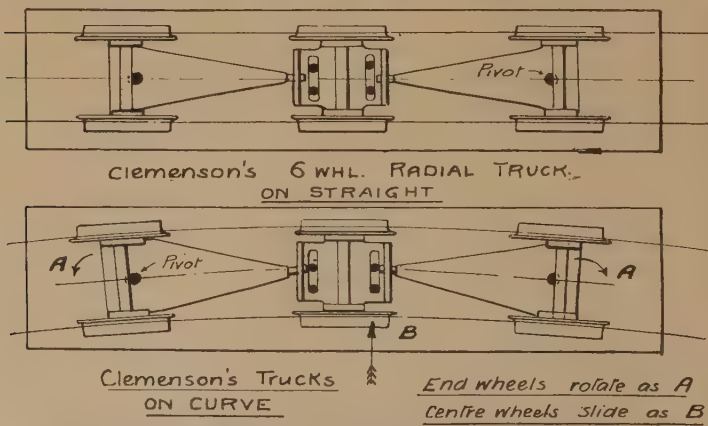


Fig. 64.—Clemenson's Six-wheel Radial Arrangement

length of the rigid wheel base and the presence of side-controlling springs or equivalent devices. The 2-4-2 locomotive, with two pony trucks (Fig. 65), whilst it is a simple and convenient arrangement, is very liable to this "nosing" action, unless one or both the pony trucks are side controlled. It should also be noted that the pony truck or radial axle is a type of bogie which, in reality, only sits truly on one particular radius of curve. The position of the

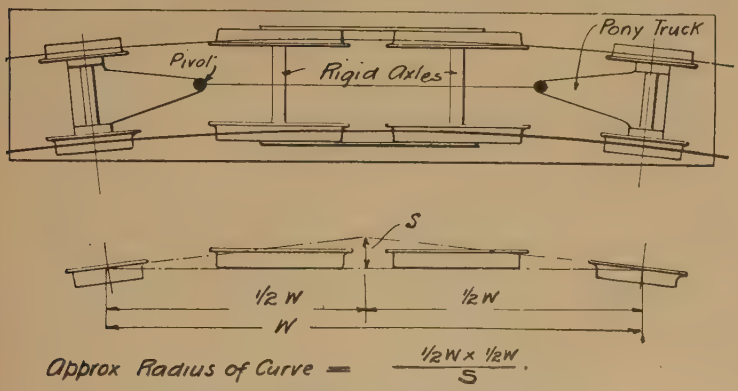


Fig. 65.—A 2-4-2 Type Engine on a Curve

pivot point in the truck should, therefore, be made to suit the average curve, not that of the smallest radius.

Types of Points and Crossings.—To assist in elucidating the construction of the numerous types of points and crossings in common use on full-size railways, the author is indebted to the N.E.R. Company for the accompanying photograph (Fig. 66) of a part of their line outside York Station. Practically the whole of the types illustrated can be modelled in a more or less degree of completeness, depending on the material employed and the gauge of the model railway.

The illustration is lettered, and the following is a list

Fig. 66.—The N.E. Railway at York Station, showing Types of Points and Crossings

of names of the various arrangements: A single crossing (i.e. right-hand point), B diamond crossing, C single-slip crossing, D double-slip crossing, E crossover road (trailing), F scissors crossover, G a special form of scissors crossover.

Where one rail crosses another the form of rail connection is known as a crossing or frog, and there are two types in general use on the above line. The V type, shown in Fig. 67, is that which is comprised in practically every simple "turnout" (see A in photograph, Fig. 66). The diamond crossing (B) introduces the K-type frog at two points of the diamond formed by one track completely crossing another one at an acute angle (see Fig. 68). Right-angle crossings are somewhat rarely used, engineers avoiding them wherever it is possible to do so, preferring the acute-angled diamond type.

In full-size practice both the V and K frogs are made up with special forms of chairs at each point of support. This is not possible in working models—at least, the trade firms supplying chair pressings and castings do not, at present, go beyond check and slide rail chairs, except, perhaps, in one instance, and this is for a large scale section of model rail not often used.

Simple Turnouts.—Ordinary turnouts, or crossings, to use the N.E.R. official term, are of two main types, i.e. trailing or facing, as illustrated in Fig. 69. In full-size practice facing points on a main line are made with as acute an angle as is possible, so that trains may take them at fairly high speed. It must be noted, however, that under no circumstances does a train turn out through facing points to the branch line at a top speed. The train invariably has to slacken. The main line portion of the points, over which trains may travel at the maximum velocity, is usually a portion of a straight (or practically

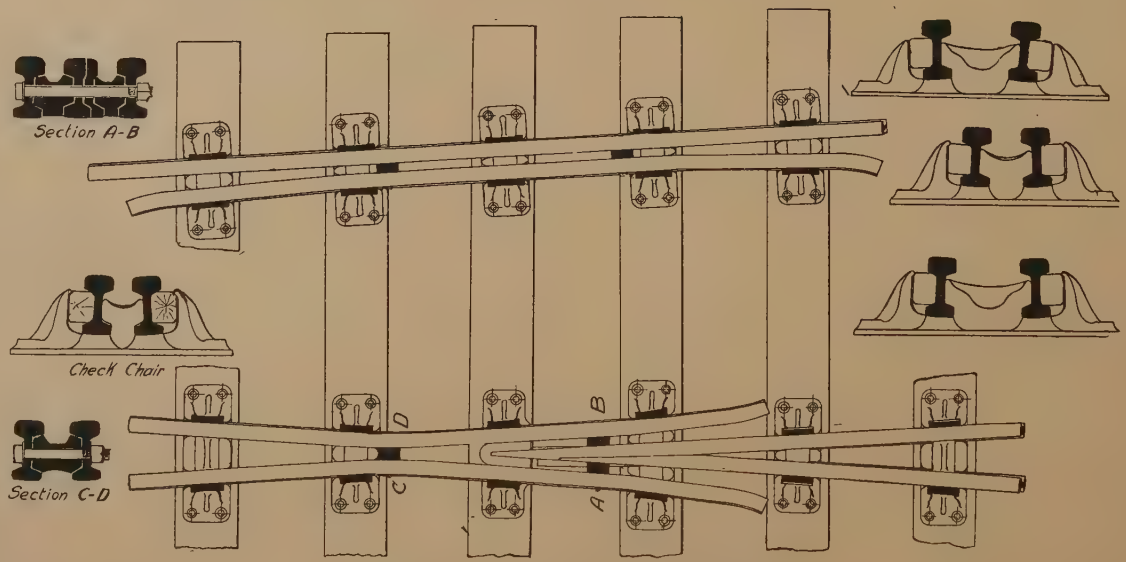


Fig. 67.—N.E.R. Standard V-crossing

straight) length of railway. Elaborate precautions are, therefore, taken in providing safety locks for facing points. Trailing points are used wherever possible in making crossings from a main line, in preference to the facing variety, as an engine or train will always force a trailing switch, even if set incorrectly and locked. In shunting sidings the point levers are not previously moved over for vehicles running in a trailing direction. This can be quite easily arranged in the larger models.

Model makers often refer to points as "right"- or "left"-hand turnouts. This is a very convenient classification. In Fig. 69 the

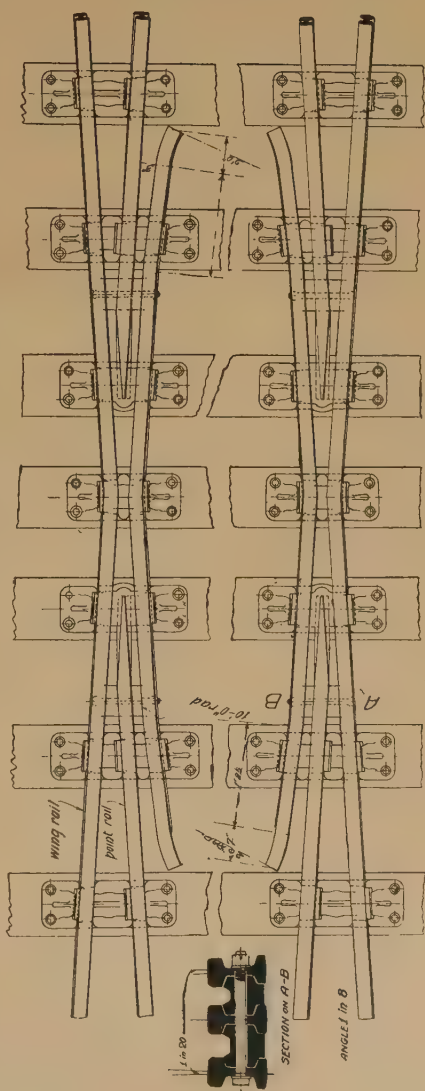


Fig. 68.—N.E.R. Standard K-crossing

trailing point branches out in a left-hand direction, and the facing point is a "right-hand" turnout.

It is always better to avoid the use of points in which the switches turn out from the inside of a curve, in the manner illustrated in Fig. 70. These points are difficult to make in a satisfactory manner, especially if the curves are at all sharp. Where the curves diverge, as shown in Fig. 71, quite a good set of points may be obtained without difficulty. It is also practicable in this type of crossing to raise the level of the frog slightly, so that there can be an appreciable amount of super-elevation of the outer rails of the curves at the point marked *g*. This type of turnout can be made to suit curves of large radii; such points will not be abnormally long.

Points on fast main lines should, if possible, be arranged to project out from straight portions. The high-speed trains can then proceed at their normal pace so long as they are continuing on the main line. If turning out to the branch, speeds must be reduced, as both in full-size and model practice it is not possible to provide any super-elevation at points and crossings, except in the case already mentioned.

Crossovers for Double Lines.—Where a line is doubled —with up and down roads—crossovers are employed. These are usually of the "trailing" type (Fig. 72), although at junctions, stations, and other parts of a railway system "facing" crossovers (Fig. 73) have to be installed to provide for the necessary train operations. The length (L, Fig. 72) of a crossover depends not only on the radius of the curve R, the gauge and the dimensions of the six-foot way S X, but on the presence of any straight road in the centre between the two turnouts. The minimum length is obtainable—other things being equal—when the two radii of the

track centres touch each other, as shown in Fig. 74. In the crossover shown by Fig. 72 the overall length is increased slightly. The radius finishes at the frogs, so that the short length *b* is a piece of straight track. The angle of the frog is measured at *a* (Fig. 72).

Fig. 70.—Curved Points with Inner Turnout

Fig. 71.—Diverging Curved Points

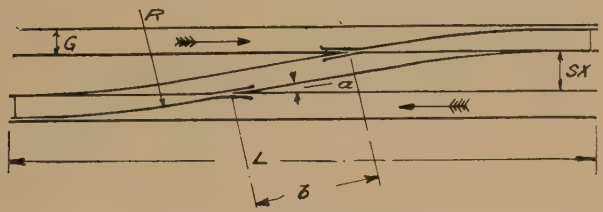


Fig. 72.—Trailing Crossover

Fig. 69.—Trailing and Facing Points

The author prefers to include this short portion of straight track in designing a crossover, as the disadvantages of the S curve where long vehicles are used are well known, and are sometimes serious. Quite a small straight section mitigates these objectionable features. As a rule,

it will pay the builder to make up triangular and diamond sections of the track carefully to drawings set out to the full size of the model as complete units.

Double or "Scissors" Crossovers.—Exigencies of space in stations and other depots lead to the installation of twin crossovers. The facing and trailing crossings are superimposed, both occupying the space of one. Fig. 75 is a typical lay-out. In designing such a crossover it will simplify construction to allow a larger amount of straight track than that recommended for single crossings (see Fig. 72). The straight portion should extend from x to y. The frogs at z are combinations of the **V** and **K** type. The construction will vary not only with the gauge and dimensions of the "six-foot" way, but with the material employed.

Double Junctions.—Such turnouts are very common, but proportionately are not so frequent in a model line as in full-size railways. They are not very difficult to make, and involve two sets of points and a diamond crossing. In real practice the wing rails of the **V** frogs and the check rails inside the diamond are quite separate. For a small model it is often necessary to extend one into the other, as shown in Fig. 76, the check rails inside the diamond forming one frame of rails.

In arranging levers and interlocking, it is obviously essential that if the "up" points are set for a train from the branch, the "down" points should be placed in a similar position. This can be done outside the signal box by fitting the two point rods close together and providing suitable stops on them. The "down" points must, however, be quite free to move in either position when the "up" points are set for the main line. The simple device shown in Fig. 77 allows for this. Normally, the two stop plates are nearly touching each other, and the "down" lever

Fig. 73.—Facing Crossover

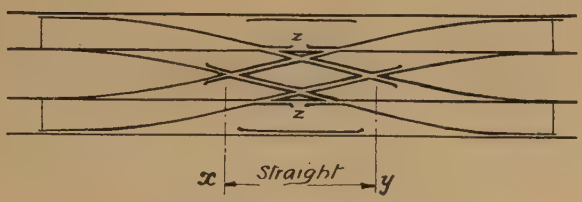


Fig. 75.—Scissors Crossover

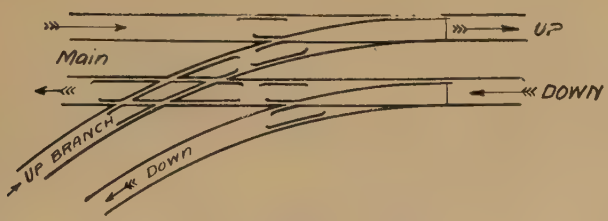


Fig. 76.—Double Junction

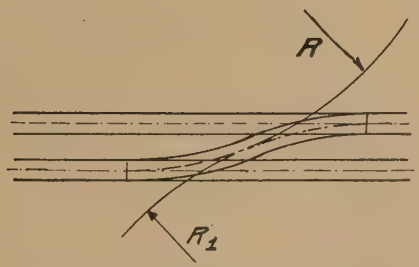


Fig. 74.—Setting Out Crossovers

must be pulled over and its stop (1) cleared out of the way before the "up" lever (2) can be shifted; No. 2 then locks No. 1.

Slip Crossings.—Ordinarily the diamond crossing provides no connection between the roads which intersect each other. Railway engineers have, therefore, introduced what are termed "single" or "double slips." The single slip allows a train to pass in either direction from one road to the other, but to make the connection truly universal in its operation two sets of slip points are often included. The two types of slip points are illustrated in Figs. 78 and 79, and from these diagrams it will be seen that it is essential that the diamond crossing which forms the basis of the lay-out shall be sufficiently acute to allow the slip points to be placed within the diamond, the radius of the connecting curved portion being commensurate with curves usually employed on a given model-railway system. As the details of the working permanent way and wheels must be coarser than the scale equivalent, the proper arrangement at the **K** frog, shown in the sketch (A1, Fig. 79) cannot be adhered to. Sometimes this check rail is omitted in small models, but some such arrangement as that shown at A, Fig. 78, is to be recommended. This is, however, not always possible in small gauge lines, as can be judged by the setting out of the slip points for a model No. 0-gauge railway, illustrated in Fig. 80. Here the check rail consists of a piece of metal (A2) soldered to the fixed part of the slip road. Indeed, both the rail and this piece which forms the check rail may be one piece of metal. Another suggestion is to make the check rail out of a piece of angle brass. This may be filed to the shape shown in Fig. 81, so that it will clear the chairs holding the slip rails.

In laying slip points, it is necessary to provide adequate

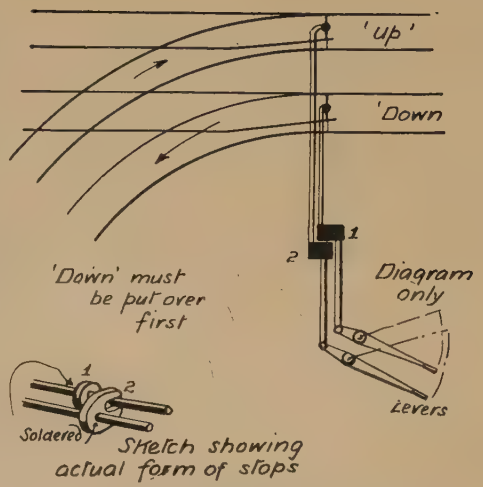


Fig. 77.—Interlocking Points of Double Junction

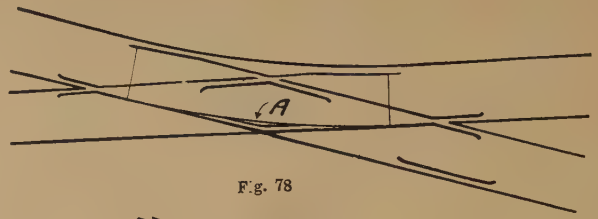


Fig. 78

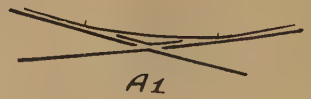


Fig. 79

Figs. 78 and 79.—Single Slip Diamond Crossing

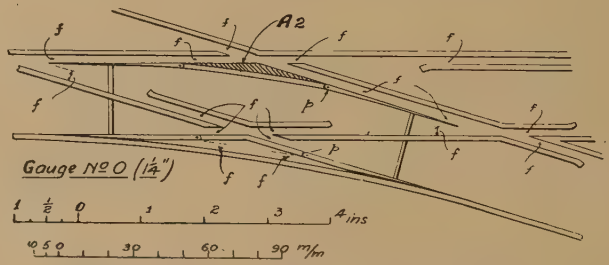


Fig. 80.—Detail of Frog for No. 0-gauge Model

clearance (i.e. the proper check rail spacing for the particular permanent way material and standard between-tyre distances adopted) for the wheel flanges at the location of the points marked *f* in Fig. 80 on page 63.

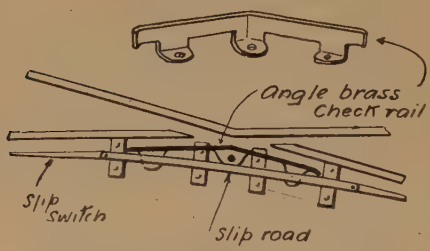


Fig. 81.—Check-rail Details for Slip Crossings

Double slips are, naturally, much more difficult to make, but the author has seen excellent examples made in No. 0 ($1\frac{1}{4}$-in.) gauge by using the smallest size of model scale keyed permanent way material that is marketed, and already dealt with in other pages.

Diagrammatic Representations of Points and Crossings. As the drawing of points for the purpose of rail planning in the true-to-scale style is a laborious proceeding, the method shown in Fig. 82 is often adopted; X is an ordinary crossover, Y ordinary points, Z a single slip, and W a double slip. The safety points at U are fitted to protect the main line from any attempt to push a vehicle out of the siding on to a main line. The standard points

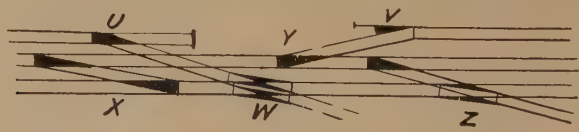


Fig. 82.—Diagrammatic Illustration of Points and Crossings

are often used in conjunction with a short dead-end siding, but sometimes only one rail is disconnected by a single-tongued switch. This is represented at V in the diagram.

Laying Points on Battens.—When points, and track generally, made up of chaired-model permanent way

material on wood sleepers are purchased ready-made, manufacturers supply the railway laid on longitudinal wood battens (see Fig. 83). The amateur who uses only the railway materials, has a permenant base for his line, and does all his own platelaying, may dispense with such battens. They are, however, necessary to keep the purchased track together during transit, but once used cannot very well be removed. When laid down, the battens are covered by loose ballast. Where the railway is not a permanent structure

Fig. 83.—Points on Battens by the Leeds Model Co.

and is only laid down when it is to be used, then the batten scheme is essential.

Scotch Block in Place of Satety Points.—In model work such is, perhaps, a refinement which may be eliminated or substituted by a swivelling log of wood or scotch block, which swings over the rails at the end of the siding when the points are set for the main line. Such devices are often met with in practice.

CHAPTER V

Model Points and Crossings

Method of Calculation.—Before going into the why and wherefore of railway point design, Fig. 84 and its accompanying table should be studied. In practice, a point is

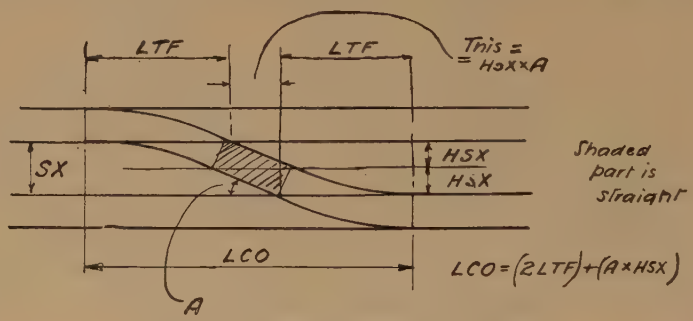


Fig. 84.—Standard Dimensions at Frogs

TABLE V.—TRIGONOMETRICAL TABLE

Frog Angle	*Radial Angle*	*Cotan.*	*Sin.*	*Vers. Sin.*
1 in 3	18°-26′	3·0003	·3162	·0513
1 in 3¼	17°-6′	3·2505	·294	·0442
1 in 3½	15°-56′	3·5028	·2745	·03842
1 in 3¾	14°-56′	3·7495	·2577	·03377
1 in 4	14°-3′	3·996	·2428	·02984
1 in 4¼	13°-14′	4·253	·229	·0266
1 in 4½	12°-32″	4·499	·217	·02383
1 in 4¾	11°-53′	4·752	·206	·02143
1 in 5	11°-18′	5·005	·196	·01938
1 in 5½	10°-18′	5·503	·179	·01611
1 in 6	9°-27′	6·008	·1642	·01357
1 in 6½	8°-45′	6·497	·1521	·01164
1 in 7	8°-8′	6·998	·1415	·01006
1 in 8	7°-7′	8·01	·1239	·0077

TABLE VI.—PERMANENT-WAY CALCULATIONS

Angle of Point		*Gauge ÷ Radius = V*	*L T F = Sine × R*	**Trigonometrical*
Approx.	*Cotan.*	*Versed Sine*	*Sine*	*Angle in degrees*
1 in 7	6·9972	·01006	·1415	8°-8′
1 in 6½	6·4971	·01164	·152	8°-45′
1 in 6	6·0080	·01357	·164	9°-27′
1 in 5½	5·5020	·01611	·179	10°-18′
1 in 5	5·0045	·01938	·196	11°-18′
1 in 4½	4·5045	·02377	′217	12°-31′
1 in 4⅓	4·303	·02596	·226	13°-5′
1 in 4	4·0009	·02984	·243	14°-2′
1 in 3⅞	3·9231	·03098	·247	14°-18′
1 in 3½	3·4912	·03866	·275	15°-59′
1 in 3¼	3·2505	·04421	·294	17°-6′
1 in 3	3·0003	·05131	·316	18°-26′
1 in 2⅞	2·8743	·05553	·328	19°-11′
1 in 2¾	2·750	·06021	·342	19°-59′
1 in 2⅝	2·6256	·0655	·356	20°-51′
1 in 2½	2·5002	·0715	·371	21°-48′

* This column is only needed where reference is made to standard tables and does not concern the model-maker.

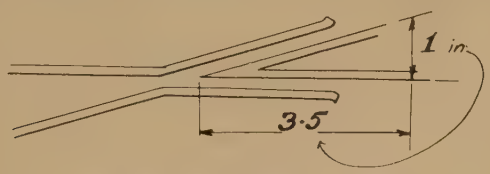


Fig. 85.—The Angle of a Frog

nearly always classified by the angle of the frog. It is stated as a point with a 1 in 4, a 1 in 6, or a 1 in 8 frog, as the case may be (see Fig. 85). This angle (A, Fig. 84) is measured at the apex of the frog, tangentially to the curve which may be present in the branch line at this part of the crossing. This angle is a trigonometrical function of the radius of the curve and the gauge of the railway. This is also true with reference to the theoretical length (see L T F,

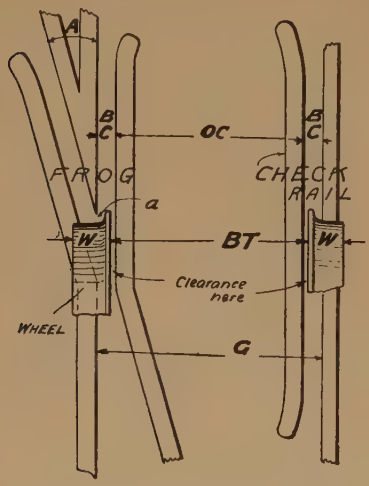


Fig. 86.—The Layout of Crossovers

Figs. 84 and 88), between the toe of the switch and the apex of the frog. The actual length may be slightly shorter, as it is impossible to point the ends of the switch and the frog to sharp knife edges.

Actually, the toe of the switch in a model falls at a point within the T.G. line (i.e., nearer to the frog). This is due to the fact that the tapering of switch rails cannot be made to scale. The tongues are relatively blunt, and the switch rails therefore shorter than the theoretical length. This must be allowed for in fixing the position of the set in a cranked stock-rail.

The angle stated in the above manner is identical with the cotangent of an angle whose *radius* is unity, while gauge divided by *radius* = a dimension termed V:

$$\frac{G}{R} = V, \qquad \text{or } R = \frac{G}{V}$$

where V is the *versed sine* of that angle.

The theoretical LTF dimension is the same as the *sine* of the angle, therefore ordinary trigonometrical tables may be employed rapidly to calculate point dimensions. A selection (Table V) from

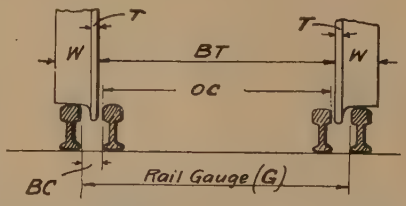


Fig. 87.—Vertical Section of Rails and Wheels at Crossings

such a table is included herewith.

If the radius of a $1\frac{3}{4}$-in. gauge set of points is required to be found and the angle of the frog is given as, say, 1 in 4, then referring to the table on this line, we find that the *versed sine* (the V dimension) is .02984. We know that

$$R = \frac{G}{V}, \text{ therefore}$$

$$R = \frac{1.75}{.02984} = \frac{175}{2.984}$$

$$= R = 58.65$$

$$= 58\tfrac{5}{8} \text{ in.}$$

If the radius is known, then the angle of the frog is found by solving $\frac{G}{R} = V$. When the value of V is obtained, look at the nearest *versed sine* in the table, and on the

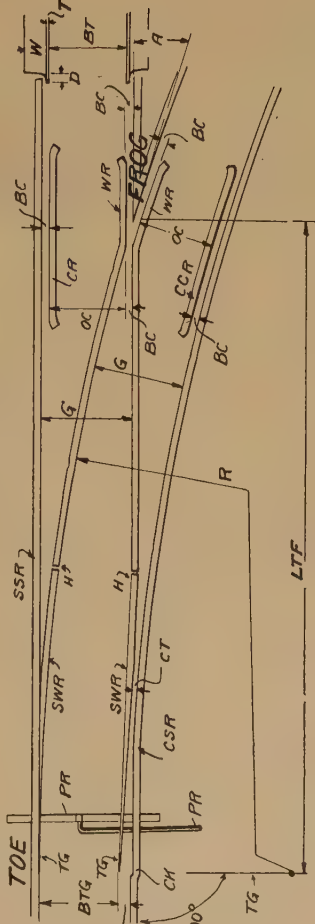


Fig. 88.—Component Parts and Important Dimensions of Points.

Names of Parts. For Dimensions see Table No. IV

BT	Between wheel tyres	R	Radius of curve	G	Rail Gauge	SSR	Straight Stock Rail
BTG	Between Tongues of Switch	TG	Line 90° to Tangent of curve at Toe	SWR	Switch Rails	CR	Straight Check Rail
BC	Between rail and check rail opposite	R	Radius from TG line	TG	Tongues (Toe of Switch)	CCR	Curved Check Rail
OC	Over check and wing rails	LTF	Length Toe to Frog	H	Heel of Switch	WR	Wing rail of Frog
CT	Clearance at Tongues	A	Angle of Frog: a function of the radius and the gauge	CSR	Curved Stock Rail	PR	Point rodding
G	Gauge as laid			CK	A Cranked Stock Rail	A	Angle of Frog

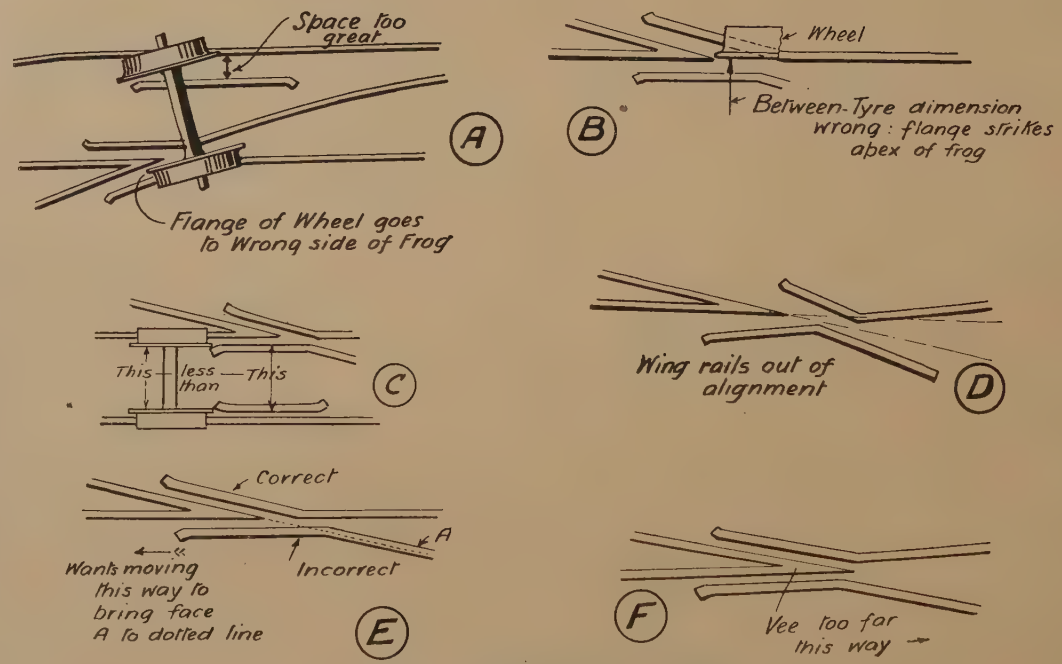


Fig. 89.—Faults Possible at Crossings

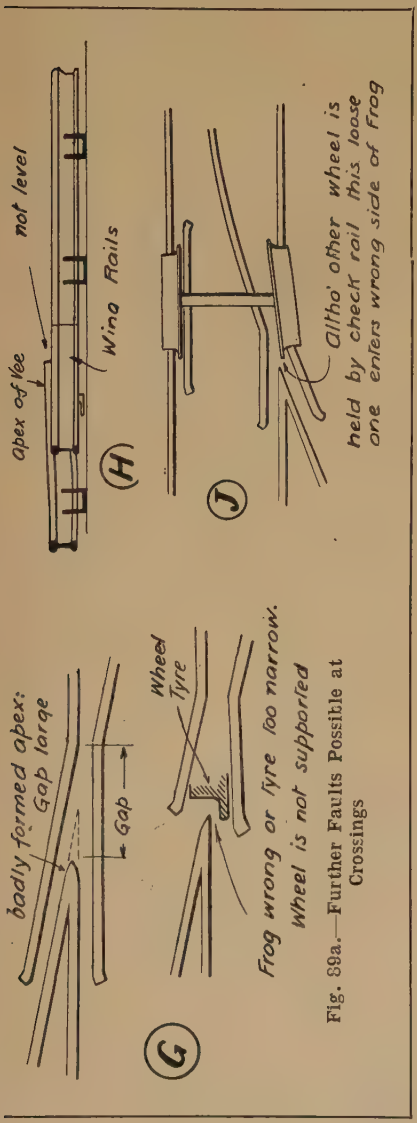


Fig. 89a.—Further Faults Possible at Crossings

same line the angle of the frog will be found without further calculation.

Length of the Crossover.—For the length of the crossover, the radius must be determined. If it is already known, then by the

$\frac{G}{R} = V$ equation, find

the *sine* on the same line in the table as the value of V. Multiply this figure by the radius and the result will be the required dimension L F T. Thus, in the case already worked out (1 in 4 crossing, $1\frac{3}{4}$-in. gauge, $58\frac{5}{8}$-in. radius) the *sine* is .243, therefore L F T = .243 × 58.6 = 14.23 in.

To find the length of a crossover where there is a short piece of straight track between the two frogs, as shown in Fig. 84 (and

Fig. 72, Chapter IV), the following formula may be used:

$$LCO = (2 \times \textit{sine} \times R) + (HSX \times \textit{Cotan.})$$

or

$$LCO = (LFT \times 2) + (HSX \times A)$$

where R = radius, *sine* = value as table, *Cotan.* = value as table, LFT = length from toe to frog, A = angle of frog (e.g. the 4 of the 1 in 4), and HSX = half of "six-foot" dimension.

The Wheel and the Frog.—The rolling of the flanged railway wheel over the frog of a crossing is often imperfectly understood, and this deficiency leads to trouble when the builder comes to point-making. Fig. 86 shows a wheel passing over an ordinary **V** crossing. While the check rail CR must restrain the flange from striking the apex of the frog at *a*, when it passes the gap the "between-tyre" distance BT must be greater than the dimension (OC) over the outsides of the opposite check and wing rails, otherwise the wheels, being fixed to their axles, will bind, and the train will be retarded, if not derailed. But the space BC must not be too open, otherwise the efficiency of the check rail will be nullified.

From the explanation of this small item in the fundamentals of point-laying, it will be seen that utmost care must be exercised to see that all the standard dimensions are worked to within close limits of accuracy. The "between-tyre" and "rail-gauge" dimensions are the vitally important factors, as will be seen by reference to Figs. 86, 87 and 88. The width of the wheel tread (W) of a model vehicle is greater than the equivalent scale dimension, because of the coarseness of the wheel flanges and the larger gap necessary at the frogs in small gauges. In rolling over the gap the tread of the wheel should not leave the

wing rail until it is supported by the apex of the frog, and *vice versa*.

As there are so many possibilities for errors in one part of the work or the other, Fig. 89 has been prepared to illustrate some of these faults. At A the space between the stock rail and the check rail is so great that the wheel has no guide when it arrives in a facing direction at the apex of the frog. Instead of being prevented, as at *a* (Fig. 84), from striking the apex of the crossing, the wheel will just as likely pass down the other space at an angle to the straight road, and derail the vehicle. Wheels loose on their axles or with a plus error in the B T dimension will do the same thing (B, Fig. 89), while if the wheels are fixed with a minus error the vehicle will derail or bind at the check rails of a crossing.

Should there be slight differences in the between-tyre dimensions of the various vehicles on the line (and assuming the errors cannot be corrected), there is nothing against arranging the space at the wing rails to be slightly larger than the space at the check rails. The difference should equal the amount of the error, the O C dimension being, of course, slightly less than the smallest distance between tyres. (Compare Figs. 88 and 90.) The sketch (D) shows a badly-placed frog. Looking along one rail at the level of the drawing (or the actual frog) it will be seen that the running edges of the rails do not line up. The continuity of the rails should be unbroken, except for the actual gap. (E) is a similar fault involving one rail only. The sketch (F) shows the apex of the frog pushed too far in between the wing rails, so that not only is the alignment bad, but the clearance between the wing rails and the V is too small to allow a wheel to pass through in a trailing direction.

The diagram G (Fig. 89) shows a large gap at the frog.

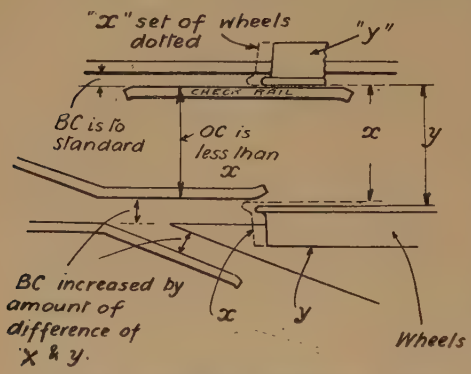


Fig. 90.—Differential Spacings for Wing and Check Rails

This will cause the wheels to bump at the V instead of passing smoothly from one rail to the other. There are several things which will create this trouble. The apex of the frog may be badly formed, the wheel tyres may be too narrow in proportion to the necessary gap, or the frog may be wrongly laid out, the space between the wing rails and the V being more than normal, or other similar errors may

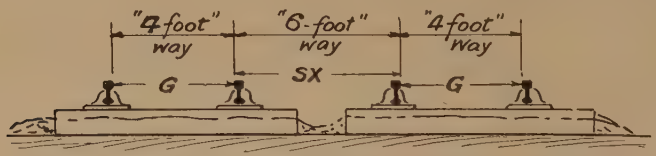


Fig. 91.—Standard "Six-foot" and "Four-foot" Ways

be present. Whatever the cause, the result is that the wheel-tread is not supported during the whole time it is traversing the frog.

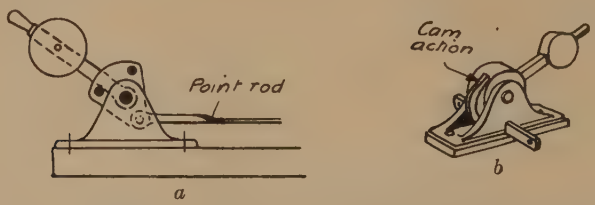


Fig. 92.—(*a*) Weight-action Lever. (*b*) Positive or Cam-action Lever

Another common fault is a "surface winding" in the tracks at the V. This may be due to the rails being badly bent during the preliminary work of forming the wing rails and apex rails. It is difficult to diagnose this imperfection, because of the varying characteristics of the track material that may have been employed. Only in one size of model permanent-way materials (the $3\frac{1}{2}$-in. gauge, $\frac{3}{4}$-in. scale) are proper frog angle-chairs made. In all others improvised methods of construction are adopted, some of which are not so good as others. The fault is illustrated in the side elevation of the track at rail level (H, Fig. 89). Again, trouble may be caused by the rail gauge not being true to dimensions at frogs and other crossings.

The sketch (J) shows a wheel which is loose on its axle or otherwise wrong (in a plus degree) in the between-tyre dimension, derailing at the V of a crossing when running through in a facing direction.

From these notes the reader will be able to avoid many of the pitfalls which the novice may encounter. The careless or unskilful permanent-way man seldom obtains a road free from derailments, even with perfect rolling stock, and therefore in laying in a set of points or any other crossover a full-size sketch should be made and adhered to as closely as possible. Where the line is laid on planed baseboards the outline of the crossing may be set out on the substructure of the line, no other drawing being necessary.

TABLE VII.—MODEL SIX-FOOT WAY STANDARDS

	Gauge		*Six-foot*		*Double road width*	
	in.	*m/m*	*in.*	*m/m*	*in.*	*m/m*
Gauge No. 0	$1\frac{1}{4}$	32	$2\frac{1}{8}$	55	$4\frac{5}{8}$	119
Gauge No. 1	$1\frac{3}{4}$	45	$3\frac{5}{16}$	84	$6\frac{7}{8}$	174
Gauge No. 2	2	51	$3\frac{1}{2}$	90	$7\frac{1}{2}$	192
Gauge No. 3	$2\frac{1}{2}$	64·5	$4\frac{3}{8}$	111	$9\frac{3}{8}$	238

Point Levers.—In full-size railway practice these are only employed in shunting yards. On the main line all points are moved from a signal-box or its equivalent. The model maker, in the initial stages of his work, however, uses point levers extensively. The cam-action lever illustrated at (*b*) Fig. 92 is self-locking, but where the points are sufficiently sensitive to movement, so that they can be operated by the weight of the vehicle in a trailing direction, then a weighted lever with a bias in either direction, such as illustrated at (*a*) Fig. 92, may be used. As a rule, the application of such a lever is limited to larger outdoor model railways.

Superelevation of Outer Rails. — The maximum superelevation given to the outer rail may be determined by the following formula:

$$\text{Superelevation in inches} = \frac{V^2 \times S \times (H - G)}{R}$$

where:

V^2 is the average speed in miles per hour, squared.

S is the scale of the model in inches to the foot.

R is the radius of the curve in inches.

H is the height of the boiler in inches.

G is the gauge of the railway.

The factors H and G are introduced into small-gauge models to allow for the relatively large amount of water in the boilers and other masses which are liable to shift. Above 1-in. scale the formula may be modified thus:

$$\text{Superelevation} = \frac{(V^2 \times S) + (H - G)}{R}$$

CHAPTER VI

Model Permanent Way Material

ONE of the greatest difficulties experienced by the model railway worker of twenty years ago was the purchase of a suitable material for his permanent way, a material which would not only serve his purpose, but would look something like a real railway in miniature. Before this time the author was quite happy with a model railway with rails consisting of hardwood strips nailed down to a baseboard. Other friends interested in the same hobby used strip-iron knocked into saw cuts in the sleepers, or the ribs of old umbrellas laid on continuous sleepers like the old G.W.R. broad-gauge track, the ribs being nicked with a three-cornered file to pierce them for the holding-down spikes.

This state of things has been altered by the modern model manufacturer. Knowing the demand, more than one of the firms now trading in this business are able to place orders with the rolling mills for quite realistic model rails to be supplied by the ton. There are at the present time a number of sections stocked by retail dealers, and quite small quantities can be obtained.

Square Iron.—This was a favourite material for outdoor railways. The section usually employed for the 3½-in. gauge lines, so common two decades ago, was ¼ in. square. The "rail" (Fig. 93) was drilled with ⅛-in. countersunk holes at every sleeper and secured by suitable wood screws. The result was not altogether satisfactory. The screws and screw holes caused trouble, and the whole track had to be smoothed up with a file and the inner arris of the square section rounded off to suit the wheel tyre and flange.

Angle and T-iron.—About the same period small ($\frac{3}{8}$-in.) angle and T-iron could readily be obtained. This was dealt with in a similar manner to the square iron, the screws being driven through the horizontal flange, as shown in Fig. 94. Round-headed screws could be used in this case, the advantage accruing from the use of either of these materials being that the labour in filing off projecting screws and rounding the running edge of the rail was saved. The drawbacks were many. The edge of the angle which supported the wheel head was narrower than desirable. The material more often than not arrived very much bent and twisted, requiring great care and skill to put things right. Another trouble was experienced with angle iron in bending it for curved sections of the line. This difficulty was less pronounced in the case of the T-section. Of the two the T-iron had a better appearance when laid.

Strip Iron Fixed into Saw Cuts.—This makes quite a good railway. It can be used out of doors, but in view of the fact that proper model steel rails with an anti-corrosive coating may be obtained, it is perhaps hardly worth while to bother with this material in the smaller gauges, even for the roughest outdoor "testing" track. For a passenger-carrying line it has some merits.

The tendency for the rail to lift out of the slots in dry weather may be reduced by driving nails (carpenter's cut brads) into the sleepers, as shown in Fig. 95. Such a railway should be tarred all over if laid out of doors, the running surface afterwards being scraped clean. Other patent preservatives may be used instead of tar, if desired.

Comparative Merits of Various Track Materials.—With reference to the comparative merits of various forms of permanent way—omitting the substitutes, such as the use

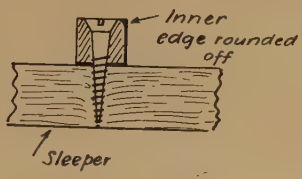


Fig. 93.—Square-iron Rails

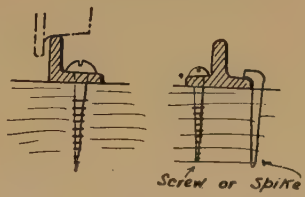


Fig. 94.—Rails of Angle- and T-Section

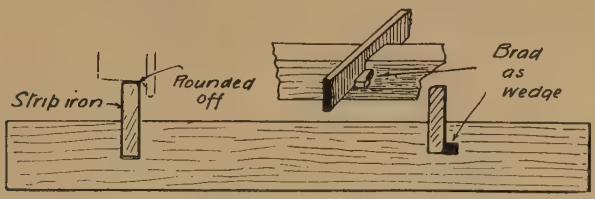


Fig. 95.—Strip-iron Rails in Slotted Sleepers

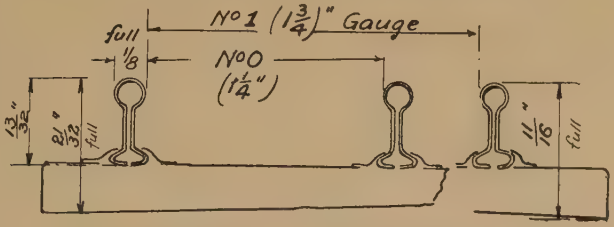


Fig. 96.—Standards for All-metal Tinplate Track

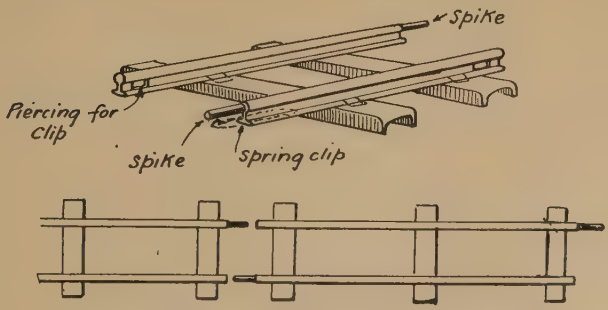


Fig. 97.—Method of Joining-up Sections of Track

of strip, angle, or other commercial forms of metal—the author would put them in the following order, dividing large passenger-carrying or miniature railways from the ordinary model system which carries the locomotives and trains only.

Permanent Way Material for Large Outdoor Lines.—*Bull-headed Permanent Way.*—The standard British practice with steel rails, cast-iron chairs, oak keys, screw fastenings, separate fish-plates with bolts and nuts.

Double-headed Iron Rail.—Otherwise as above; quite the best substitute for the scale model rail.

Flat-bottomed Rail.—For very large gauges only. Can be spiked or screw clipped. The latter scheme is preferred by author, although dog spikes may have to be employed in subsequent track repairs and maintenance.

Bull or Double-headed Rail.—Keyed into slots in sleepers. A very good substitute in all sizes, especially if wood is readily available. A deep rail is necessary, and deeper sleepers than normal.

Permanent Way Material for Small Gauge Railways.—*Bull-headed Keyed Permanent Way.*—Has cast chairs. Excellent for indoor or outdoor railways. Copper rail the best, but a good-quality brass stands many years. Chairs cast in a good white metal of the lead-antimony alloy group.

Bull-headed Rail.—Made in pressed steel spring chairs for indoor railways. The chairs for a solid rail must have some resiliency to ensure soundness in track construction.

Bull-headed Rail.—Made in cast white metal chairs without keys. This system takes the place of the above for outdoor railways, and is best used with a brass, copper, or anti-corrosive coated steel rail.

Where steel rails are used, the best method of rust prevention would appear to be a zinc coating, as applied

under the "Sherardising" process. Electrolytic deposition of copper and tin proved of no use whatever, lead was better, but thickened up the rail considerably with a relatively soft coating. "Rustless Steel" (chrome steel) would appear to be the best material from which to draw the rail, but at present the cost is practically the same as, if not more than, that of copper or good quality brass rails.

Bull-headed Rail.—In keyless chairs made of *soft sheet steel.* An indoor scheme only and a very inferior arrangement to No. 1 or No. 2.

Hollow Rail.—Has pressed metal chair spiked to wooden sleepers. In this case the chair need not be of spring metal, as the rail gives the necessary resiliency for "gripping" purposes. This rail would be better if the head were reinforced with wire, but this material is not now made. For indoor work there is not much to choose between tinplate and brass as a material for rail and chairs of this kind; although tinplate rails will eventually rust away, the material withstands wear and tear better than brass sheet. If the work of laying the track is not considered, this material is much less costly than ready-made-up tinplate rail sections.

Hollow Tin Rails on Tin Sleepers.—This is a system suited only to ready-made-up track in standard lengths. The hollow tinplate rails are made up into sections of track by pushing the rails into slits in the metal sleepers, and are clipped or soldered. The author's chief objection to this track is the fact that the sleepers are not parallel, but provide a permanent superelevation which is a nuisance. The superelevation cannot be extended to points, therefore the track is subject to a surface twist which is entirely unnecessary. English manufacturers since the war have unfortunately copied this German idea.

Hollow Tin Rail—Fitted into Wood Sleepers.—This is known as the "Simpull" track, and is not quite so sound a proposition for a portable track as the tinplate all-metal track. The fixing between the rail and sleeper is not very definite. Materials can be obtained as well as finished track, but, again, it is not much cheaper than the more satisfactory tinplate chaired road referred to in an earlier paragraph.

Tinplate Model Railways.—It was the advent of the ready-made model railway that created the demand for something better. The permanent sections can be laid down on a table or floor in various formations, and then taken up again and stored. Considerable ingenuity has been displayed by manufacturers in designing the pieces to obtain a large variety of plans from a relatively small number of components. The rails are made in standard gauges, of tinplate, pressed up into a reasonably good shape (see Fig. 96). The heads of the rails are, of course, hollow, and to make a satisfactory joint between the abutting lengths of track the rail on one side has a spike fitted to it. This engages the hollow head of the next length. All the best tinplate track is now provided with the alternate spike arrangement shown in Fig. 97, in contradistinction to the old scheme in which there were two spikes at one end of a length and none at the other.

The alternate spike system allows each end of a rail length to be joined to another, which, of course, facilitates making up different formations from a given supply of piece. Spring clips—also placed alternately—or clip wires (in the cheaper varieties of the track) are used to hold the lengths together.

The following are the dimensions of the two standards in No. 0 ($1\frac{1}{4}$-in.) and No. 1 ($1\frac{3}{4}$-in.) gauges. Tinplate track

is made in No. 2 (2-in.) and No. 3 ($2\frac{1}{2}$-in.) gauges, but both these sizes may, for railways made up of this material, be considered as obsolescent.

The rail is rather large in section, as will be seen by the full-size diagram (Fig. 96). The sleepers are cut with an inclined base. While this scheme was, perhaps, necessary with the older small-radii curves, it is not justifiable with the later larger standard radius. In any case, points have to be made with a level surface, and, therefore, the value of the canted curved sections is nullified. The radius adopted for the turn-out of points is the same as that of a curved piece. The lengths are also identical, so that a point may be made to take the place of a curved or straight length, as the case may be.

Fig. 98.—" Simpull " Hollow Tin Track

Certain difficulties arise if the user attempts to make up out of tinplate track a railway-like plan, providing loops, double lines, sidings, and platform roads in a station. He will find that the geometric formation limits the application of this kind of track. In view of the many admirable sections of both hollow and solid rails, chairs, fish-plates and other accessories which can be obtained at prices to

TABLE No. IX.

Small Radius Tinplate Track.

Gauge No. 0 ($1\frac{1}{4}$ in.)	Curves	6	pieces	to circle	—2 ft. 0 in. diam.
Gauge No. 1 ($1\frac{3}{4}$ in.)	,,	8	,,	,,	—3 ft. 0 in. diam.

Large Radius Tinplate Track.

Gauge No. 0 ($1\frac{1}{4}$ in.)	Curves	12	pieces	to circle	—4 ft. 0 in. diam.
Gauge No. 1 ($1\frac{3}{4}$ in.)	,,	16	,,	,,	—6 ft. 0 in. diam.
Straight-lengths in both sizes		Gauge No. 1, 11 in. Gauge No. 1, $13\frac{3}{8}$ in.			

suit all pockets, there is no excuse for anyone using the ordinary tinplate rail sections. It is hardly worth the trouble, for the sake of employing ready-made tinplate points, to limit oneself to the use of the large section of hollow rail material (rail, pressed chairs and wooden sleepers, see Fig. 99), just because this section happens to be the same as that of the standard tinplate track.

"Simpull" Track.—The section (Fig. 98) shows a rival to the ordinary tinplate rails. This rail slides into saw cuts in the wooden sleepers and is held longitudinally by the friction between the two parts. Except for the points and for the fact that the sleepers are of wood and are not canted as a ready-made track, it is not quite so good as the best tinplate track. Loose parts may, however, be obtained, and variations in formation may then be more easily effected.

Hollow Section Rails with Chairs and Wood Sleepers.—At the time the railway building material, to be described in this paragraph, was introduced at the author's suggestion, there were several sizes of solid rail obtainable. The idea of the "Simpull" track was to provide a material which would compare favourably in cost with the ordinary tinplate railway, and at the same time give the user the obvious advantages of a chaired road and wooden sleepers. Under no disguise can a model railway, built up with tinplate rail sections, be made to look like a full-size railway. But by using the same rail section, fitting it with a pressed metal chair spiked down to a wooden sleeper, quite a realistic line can be obtained, as will be seen from Fig. 99. With regard to cost, if one lays the line oneself and provides the sleepers, it is cheaper to use this material than to bother with ordinary tinplate track.

Two sizes of rail are made, the larger one being identical in cross-section with that used for tinplate railways. This

rail may, therefore, be employed in conjunction with the standard tinplate points and crossings. The dimensions of the larger rail may be taken from the central rail of the electric track, illustrated in Fig. 102.

The smaller rail is much to be preferred for the average indoor line. Readers will find no difficulty in making

Fig. 99.—Tinplate Chaired Track on Wooden Sleepers

points with this material, as check rail chairs are obtainable to suit it. This section (Fig. 100) is much more popular than the larger one, and, of the two, is more worthy of consideration. The rails and chairs are supplied in tinplate and sheet brass. The chairs (Fig. 100) are stamped out and folded to slide on to the rail, the hollow section of the latter providing the spring grip between chair and rail--a very essential feature in any form of chaired road.

For electric traction special chairs which lift the centre conducting rail above the running rails are made. These are illustrated in Fig. 101, while the next sketch (Fig. 102) shows the same result obtained by using the larger size of this track material for the "third" conductor rail, as explained in the companion volume, "Model Electric Locomotives and Railways."

Solid Steel Rail with Spring Slide on Chairs.—This rail, which is rolled in 3-ft. lengths, is rather larger than is really advisable for No. 0-gauged railways, although it is much used for this purpose. The author can strongly recommend it for $1\frac{3}{4}$-in., 2-in., or $2\frac{1}{2}$-in. gauge indoor lines. The chairs are made of writing-pen steel, tempered, and are designed with a slit below the supporting hole, which allows the chair to spring open when pushed on to the rail. Check rail chairs are made on the same principle, while the slide chairs are fitted with a brass supporting shoe for the rail switch to slide upon. These accessories are shown in Figs. 103 to 105, and as laid in Fig. 106.

Before the war a rail of this section was supplied with a rust-preventing coating of zinc applied by the "Sherardising" process. This certainly lengthened the life of the rail. Such a rail is, however, not absolutely essential for indoor work. The coating on the top of the rail soon wears off, especially if electric locomotives are adopted, and the line has to be frequently cleaned with glass-paper or with any other abrasive medium.

To put the chairs on to the rail, the burrs on the ends should be removed, on the lower bulb and web at least, and the chair so held that it opens out and runs on easily.

In the samples of rails the author has examined, the check rail chair (Fig. 105) would, with a section of rail having the proper web thickness, provide a "B C" dimen-

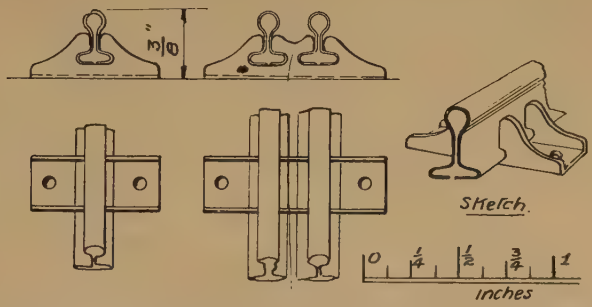


Fig. 100.—"Lowko" Track, Small Section, shown Full-size

Fig. 102.—Electric Rail made with Larger "Lowko" Section

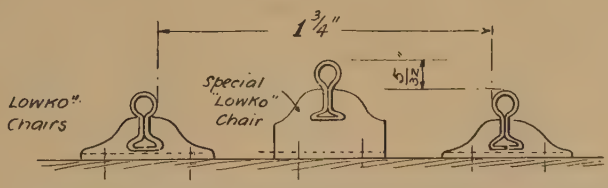


Fig. 101.—Electric Rail made with Smaller Section and Special Chairs

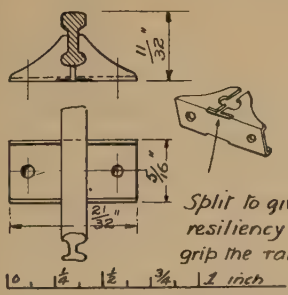


Fig. 103.—"Millbro" Spring-steel Chair and Solid Rail

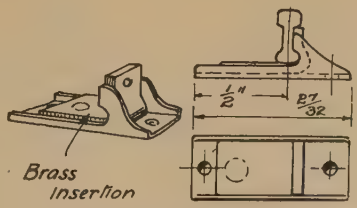


Fig. 104.—"Millbro" Slide Chair

sion of $\frac{9}{64}$ in., but measurements show that a thick web increases this to $\frac{5}{32}$ in.

Steel Rail with Cast Slide on Chairs.—There are several types of this rail. The "Millbro" rail referred to in the last paragraph (as well as other solid rails) can be obtained with cast chairs, as shown in Fig. 107, and if the rail is "Sherardised," the material is reasonably satisfactory out of doors. The "L M C" rail illustrated, among others, in Fig. 108 is, perhaps, the best small-scale rail of this kind, and is, in a measure, protected from corrosion by a tin coating. Check rail chairs are not supplied, it being the practice to cut the ordinary chairs and butt them together where check rails are necessary (see Fig. 109).

Scale Model Permanent Way.—The best form of permanent way—the standard British chaired and keyed road—is modelled in two sizes. The larger size (Fig. 110) is exactly $\frac{3}{4}$ in. to the foot, and is based on Midland Railway practice. It is recommended for railways of $3\frac{1}{4}$-in. and $3\frac{1}{2}$-in. gauge, and includes quite a large range of accessories. The rail is drawn in good quality brass, and the chairs are cast in a hard white metal. The fish-plates are cast metal, and slide on to the rail. Special chairs for frogs and diamond crossings are made to reduce the work of point-laying. Only the fact that this model permanent way was required for signalling and other instructional models by several of the large railway companies has made its production possible.

For the average user the small scale track, made by one or two firms, is more suitable. It is designed for all models of gauges from $1\frac{1}{4}$ in. to $2\frac{1}{2}$ in., and is drawn in brass. It is contended that the use of a coated steel does not lessen the cost of production sufficiently to warrant its adoption as a standard. The better material—from an anti-corrosive

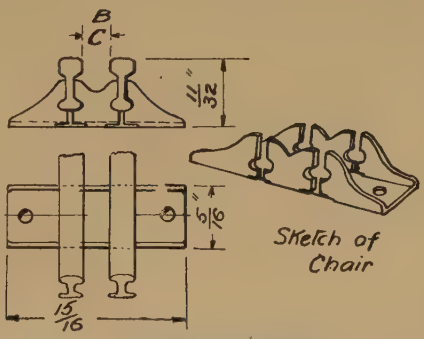


Fig. 105.—" Millbro " Spring-Steel Check Rail and Chair

point of view—may, therefore, be employed, and as brass becomes cheaper the difference between the two materials will be less. Figs. 112 to 114 show details of this track. Check rail and slide chairs are provided in cast white metal. The keys are of wood. The value of a keyed road is to be observed in making alterations to any part of a model railway. A rail can be readily removed and replaced without interfering with the chairs, as is done in real practice. With slide-on chairs it is necessary to rip up the whole section of the road to effect repairs, alterations or additions. A keyed track is also superior to one with solid rails and cast slide-on chairs, in that a proper "grip" of the rail is obtained. White metal (having a lead base) is a very inelastic material, and even if the chairs fit tightly in the first

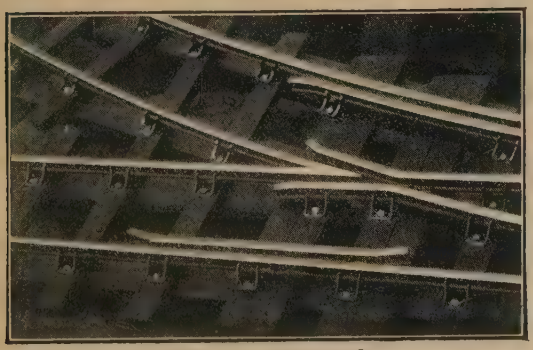


Fig. 106.—Points laid in " Millbro " Track

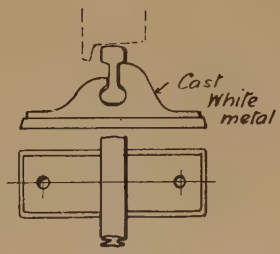


Fig. 107.—" Millbro " Rail with Cast Slide-on Chair

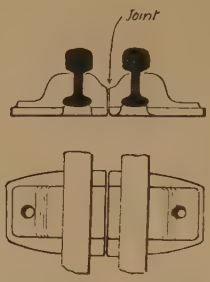


Fig. 109. — Cutting Cast Chairs at Check and Wing Rails

A

General Sections

B

American Sections

C

Bassett-Lowke Section

D

Another Bassett-Lowke Section

E

Millbro Section

F

Leeds Model Co. Section

G

Marshall Stuart Section

Fig. 108. —Model Rail Sections Printed Full Size from the Actual Rails Supplied by Manufacturers

instance, this condition is not always maintained in service, nor even during the process of laying the track. In some places, however, a slide-on chair is useful, and a firm has lately produced a cast slide-on chair to fit the rail. This is of excellent design, and includes a dummy key, as illustrated in Fig. 116, which matches the ordinary keyed chair. Spring fish-plates in brass, with bolt heads embossed on them, are included in this track material.

The basic lengths for large scale materials is 24 in. and 18 in. for the small scale rail. A fish-plate is included with each length of rail.

Fig. 110.—Bassett-Lowke ¾-in. Scale Permanent-way Material

American Flat-bottomed Rail.—Save for experience with large flat-bottomed "Vignoles"-section rail for 15-in. gauge railways, the author is not in a position to advise on the suitability of this type rail for indoor and other small gauge railways. The author cannot see how any claims for superiority over the British chaired road can possibly be sustained. Small spikes are troublesome enough in holding down chairs, but to rely on them to take up shearing stresses and to position the rail seems to be over-estimating their sphere of usefulness. With the assistance of Mr. A. W. Line, of Jamestown, N.Y., U.S.A., one model maker of note has produced the two sizes of model rail in brass illustrated in Fig. 108. The rails are based on American railroad standards, and are respectively rolled for 1¾-in.

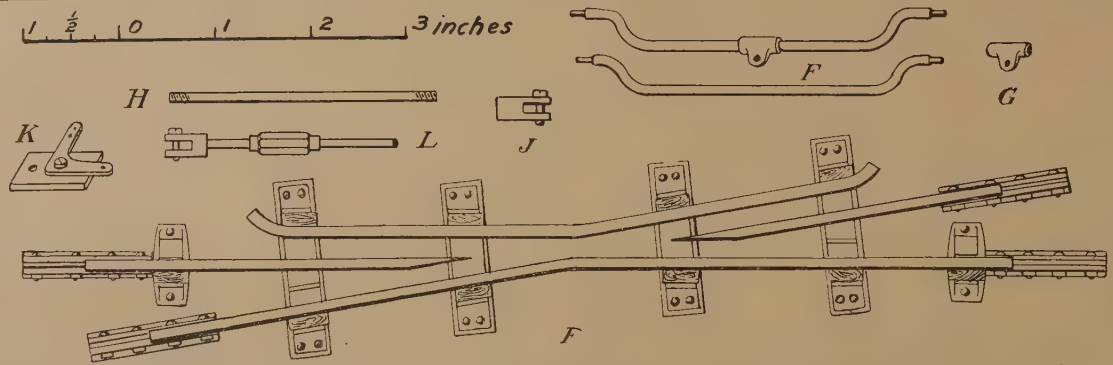


Fig. 111.—Special Parts for ¾-in. Scale Permanent Way; E, Parts for K-pattern Frog; F, Point Rods; G, H, J, L, Point-rod Connections; K, Bell-cranks for Point-rods

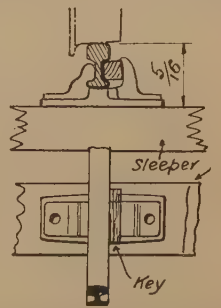


Fig. 112.— Bassett-Lowke Small Scale Permanent Way

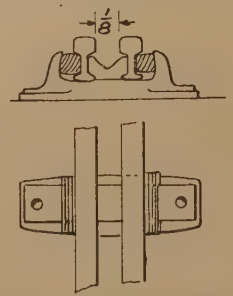


Fig. 113.— Bassett - Lowke Small Scale Check Chair

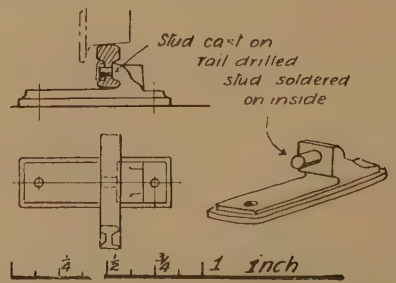


Fig. 114.—Bassett-Lowke Small Scale Slide Chair

and $2\frac{1}{2}$-in. gauge railways. The table on page 94 gives the weights of the two sections:

Scale Model Permanent Way for Outdoor Lines.—The permanent way illustrated in Fig. 117 exemplifies the correct model both in the material and the scale of the component parts. The rail is of the standard bull-head section, in mild-steel, the chairs are cast-iron made from metal patterns with the space between the jaw cored out. The keys are of oak, and the scale of the track is $1\frac{1}{2}$ in. = 1 ft. Except for certain purposes, such as for an exhibition stand

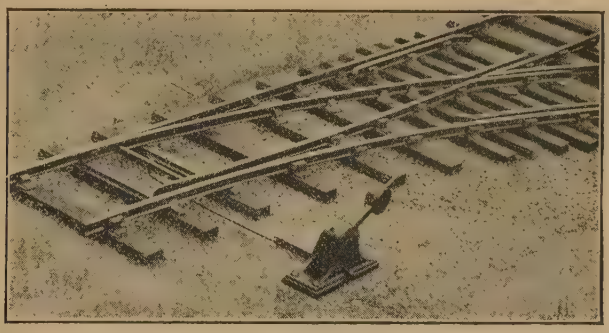


Fig. 115.—Points Laid in Bassett-Lowke Small Scale Permanent Way

for a locomotive or train, the writer would not recommend its use for working model railways over 6-in. gauge ($1\frac{1}{4}$-in. scale). It is very suitable for a passenger-carrying 1-in. scale railway. In considering the usefulness of any permanent way material for model railways on which the operator rides, it must not be forgotten that the axle loads are proportionally higher than scale. The weight of a driver on a $1\frac{1}{2}$-in. scale locomotive tender represents a load, over and above the normal 40-scale tons, of 35 tons, i.e. it practically doubles the weight the track has to support.

Before the war some similar track material was made in

2-in. scale ($\frac{1}{6}$th full size). This permanent way was used by the author for several $1\frac{1}{2}$-in. scale railways with success, the slightly heavier rail being an advantage, as already mentioned.

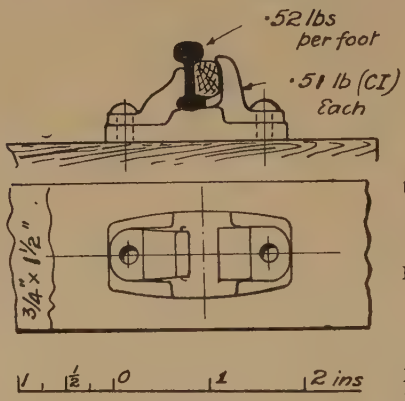


Fig. 117

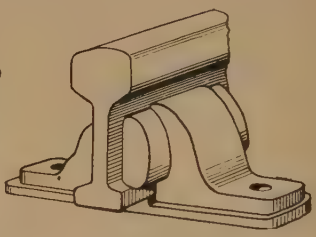


Fig. 116

Fig. 116.—Bassett-Lowke Slide-on Cast Chair

Fig. 117.—$1\frac{1}{2}$-in. Scale Permanent Way for Outdoor Railways

A Cheap Form of Outdoor Permanent Way.—The model railway engineer in need of a rail material obviously cannot afford the expense involved in rolling a section to suit his line, and if some model manufacturer does not

American Model Permanent Way

Length.	*Weight.*	
	$1\frac{3}{4}$-in. gauge.	*$2\frac{1}{2}$-in. gauge.*
1 foot	$1\frac{1}{8}$ oz.	$2\frac{1}{8}$ oz.
1 yard	$3\frac{3}{8}$ oz.	$6\frac{3}{8}$ oz.
14 ft. $2\frac{5}{8}$ in.	1 lb.	—
7 ft. $6\frac{3}{8}$ in.	—	1 lb.
100 ft.	7 lb. $0\frac{1}{2}$ oz.	13 lb. $4\frac{1}{2}$ oz.

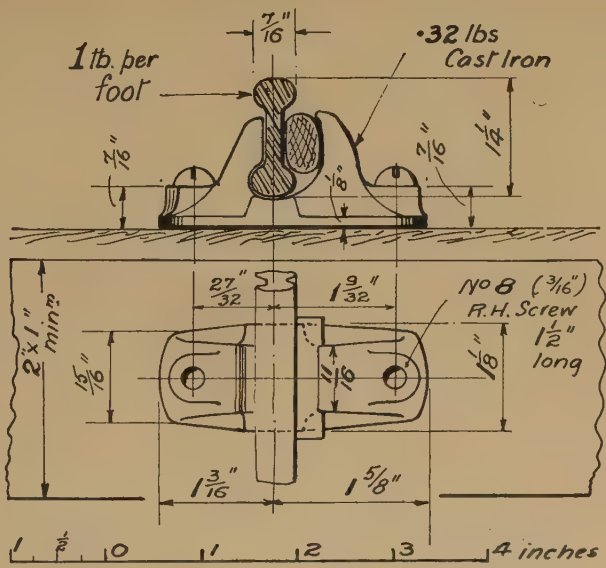


Fig. 119.—Cheap Form of Chaired Permanent Way Using Fence-iron for the Rails

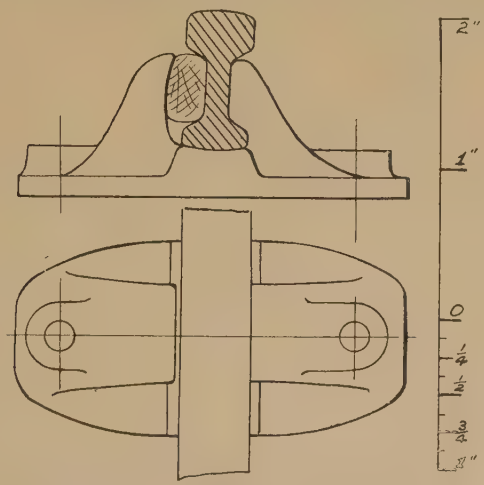


Fig. 118.—2-in. Scale Model Permanent Way

happen to have a sufficient number of customers to warrant his stocking ten or twenty tons of a scale model rail, made to his own special rolls, the amateur has to look around for substitutes. One of the most interesting discoveries in this connection was the commercial "double bulb" section of iron used for fencing purpose. The common size for this is $1\frac{1}{4}$ in. by $\frac{7}{16}$ in., and this serves excellently for railways of 6-in. to $9\frac{1}{2}$-in. gauge.

Some years ago the author got out an iron chair to suit this rail material, and many thousands were cast from this pattern. Fig. 120 illustrates a short length of this permanent way. It is, of course, a keyed road, and is extremely easy to lay. The minimum size for sleepers is 2 in. wide by 1 in. deep, twice the rail gauge in length, although the writer would recommend the use of not less than $2\frac{1}{2}$-in. by $1\frac{1}{4}$-in. battens for this purpose for railways over $6\frac{1}{2}$-in. gauge. The chairs should be cast in fine iron from a metal pattern. The chair illustrated in the photograph was arranged to mould on its side, no core box being used. The chairs are fixed to the sleepers by the ordinary commercial round-headed screws, size No. 8, $1\frac{1}{4}$ in. or $1\frac{1}{2}$ in. long. Fig. 119 shows a slight improvement on the original pattern, the cross-section directly under the rail being strengthened without increasing the total weight of the chair.

Sleepers (red deal) should be treated with creosote, sideroleum, solignum, or other similar preservative. The chairs can be fitted to the sleepers before laying the track if they are held in a suitable jig.

Keys should be moulded out of oak, in long strips cut up into pieces $1\frac{1}{4}$ in. in length.

A Chairless Keyed Permanent Way.—The cast-iron chairs used for an outdoor track of the kind described in the last paragraph cannot cost much less than 3d. each

Fig. 120.—Track Laid in Material shown by Fig. 119

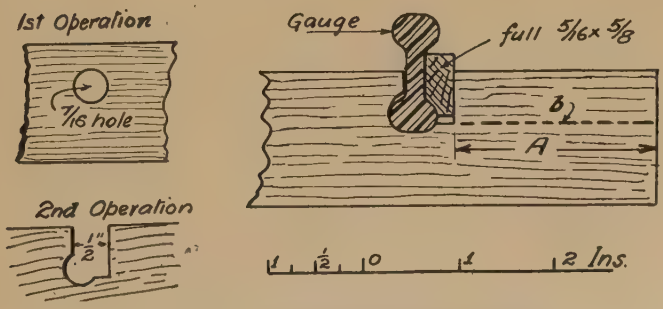


Fig. 121.—An Outdoor Track without Chairs

(retail price, including pattern charges, etc.), and if the projected line is to extend over hundreds of yards the cost of this item will be considerable. The author, therefore, has used the "fence-iron" rail held directly in the sleeper without the intervention of chairs, keys being used to secure the rail tightly.

Figs. 121 and 122 illustrate this idea. The sleeper must be larger than normal—in depth more particularly—and the overhang at the outsides (dimension A, Fig. 121) must be adequate, otherwise there will be a danger of a tight key shearing the sleeper along line *b* when it is driven in. To form the groove or slot for the rail two operations are necessary. First, a hole is bored, which will take the bottom bulb of the rail. The second operation is to mill out a slot $\frac{1}{2}$ in. wide. This can be done over the top of a circular saw (one with a rising and falling table), the saw being set "drunken," so that it cuts a wider slot than its own thickness. This is a well-known and much-used device.

Fig. 122 shows a slight improvement on that shown in Fig. 121. The key is of wedge-shape section, and would hold the rail more firmly in the sleeper. The slotting of the sleeper, however, involves three operations: (*a*) boring, (*b*) sawing, with a saw of ordinary thickness to form the inside flat face, and (*c*) cutting the angular face and wide slot with a drunken saw, the table being tilted.

A moving-table saw is the most useful for this work, and the necessary tilting can then be easily arranged by fitting angular blocks to the surface of the table.

Outdoor Keyed Chair Railways.—The practice followed in the construction of full-size railways may be adopted for outdoor models of $7\frac{1}{4}$-in. and larger gauges. The cast-iron chairs can be fixed to the sleepers before they are laid on the ballast. As there are bound to be slight

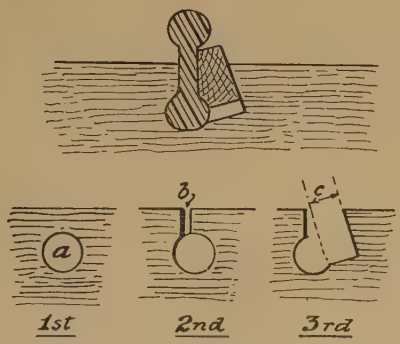


Fig. 122. — An Outdoor Track without Rails

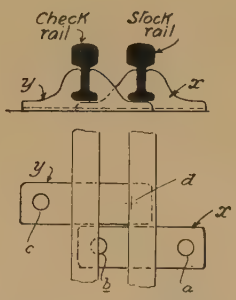


Fig. 125. — Staggered Chairs for Check Rails

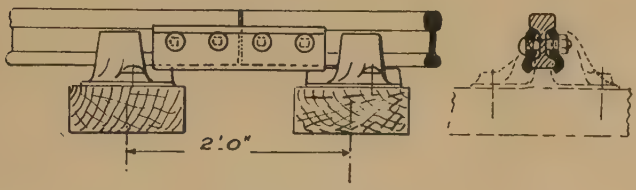


Fig. 124.—Fish-plates

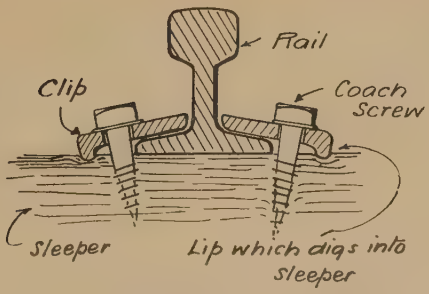


Fig. 123.—Flat-bottomed Rail for Outdoor Use

errors in the fixing of the chairs on the sleepers, even if jigs and templates are employed, it is advisable to sort sleepers into two groups after the work of chair-fixing is done. All sleepers which are found to have the chairs secured slightly over the correct dimensions—thereby increasing the rail gauge—may be marked for use on curves. The others, so long as there is no great error in the other direction, may be kept for ordinary straight track. The formation level of the earth should be made up or excavated to at least 4 in. below the level of the rails—five inches difference will not be too great if the ground is not very firm—and a 2-in. layer of gravel should then be evenly spread over the surface.

To enable the permanent way to be maintained at the predetermined levels, the course of the line should previously have been pegged out along the centre line of the track, the pegs being driven down so that their tops coincide with the final surface of the rails. When the rails are fitted in and keyed up finer ballast is filled in between the sleepers, and then tamped in to consolidate the line. Sleepers will require lifting or driving down to obtain a level track.

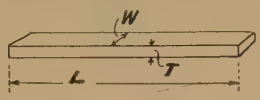
To test for "cross-wind" in the track, a spirit level is laid across the rails; straightness and continuity of surface level longitudinally being obtained by looking along the rails, while an assistant slews or lifts the rails with a suitable crowbar.

The soundness of an outdoor railway very largely depends on the use of sleepers of adequate size—a section of wood double the scale equivalent is a safe rule—and on plenty of good ballast. Sleepers should not be placed too far apart. A good plan is to space them three sleepers' width from centre to centre. As cast-iron chairs are an ex-

pensive item on a long track, the fact that large sleepers are used will tend to reduce the cost of the railway.

Track for Light and Miniature Railways.—For the type of model railway which goes under the term of "Miniature Railway"—usually 15-in gauge—such as is laid down in pleasure parks, exhibitions, etc., for carrying children, a flat-bottom rail is used. Rails weighing 12 lb. per yard can be used with engines of less than $1\frac{1}{2}$ tons

TABLE VIII.—SLEEPER SIZES



	W	*T*	*L*
Gauge No. 0 ..	$\frac{1}{2}$ in. or $\frac{3}{8}$ in.	$\frac{9}{32}$ in. or $\frac{1}{4}$ in.	$2\frac{1}{2}$ in. to 3 in.
Gauge No. 1 ..	$\frac{9}{16}$ in. or $\frac{1}{2}$ in.	$\frac{5}{16}$ in. or $\frac{9}{32}$ in.	$3\frac{1}{2}$ in. to 4 in.
Gauge No. 2 ..	$\frac{9}{16}$ in. or $\frac{1}{2}$ in.	$\frac{5}{16}$ in. or $\frac{9}{32}$ in.	4 in. to $4\frac{1}{2}$ in.
Gauge $2\frac{1}{2}$ in. ..	$\frac{5}{8}$ in. or $\frac{9}{16}$ in.	$\frac{5}{16}$ in. or $\frac{9}{32}$ in.	5 in. to $5\frac{1}{2}$ in.
Gauges $3\frac{1}{4}$ in. & $3\frac{1}{2}$ in.	$\frac{3}{4}$ in. or $\frac{11}{16}$ in.	$\frac{3}{8}$ in. or $\frac{11}{32}$ in.	$6\frac{1}{2}$ in. to $7\frac{1}{2}$ in.
Outdoor lines on Earth			
Gauge $4\frac{13}{16}$ in. ..	2 in. or 3 in.	1 in. or $1\frac{1}{2}$ in.	10 in.
Gauges $7\frac{1}{4}$ in. & $9\frac{1}{2}$ in.	4 in. or 5 in.	2 in. or $2\frac{1}{2}$ in.	20 in.
Gauge 15 in. ..	4 in.	8 in.	3 ft. 0 in.
„ (heavy engines)	5 in.	10 in.	

weight in working order if the sleepers are adequate in size and number. A 16-lb. per yard rail is much easier to maintain in perfect condition, while on some lines with 3-ton engines the writer has specified 18- and even 20-lb. rail.

The contractor's type of railway with four or five small pressed-steel sleepers per 15-ft. length of rail should not be employed for a permanent line, and in place of the usual spikes the author prefers clips and coach screws, as detailed in Fig. 123. The holes for the coach screws can be jig-drilled before laying the sleepers.

Fish-plates.—For small-scale railways the spring fish-plate is the best. It is slid on to the ends of the rail. The latter should, therefore, always be trimmed up with rounded edges, so that the fish-plate can be fitted without undue trouble. When a rail is to be removed the fish-plates can be forced along on to the rail which is not to be disturbed, and returned when the other rail is replaced. This form of fish-plate was introduced by Mr. Geo. Winteringham, and was originally made in white metal (see Fig. 110) for the $\frac{3}{4}$-in. scale standard permanent way.

For large outdoor passenger-carrying models the orthodox fish-plate is employed, four bolts per pair of fish-plates being used. Rail joints should always be opposite to each other.

Check Rails.—It is the practice of one model-making firm to cut ordinary chairs (as shown in Fig. 109) to make provision for check rails. It is also possible to use ordinary chairs staggered, as shown in Fig. 125. To do this successfully everything depends on whether the feet of the chairs will pass under the rails when they are placed at the correct distance apart. White-metal chairs can easily be cut, while cast-iron ones can be filed down. With pressed-spring steel chairs it is not possible to alter the chairs. Another point is the fixing. The running or stock rail chair (x) should certainly be fixed completely, both ends a and b being spiked down. It may only be possible to spike down the check-rail chair at c, the hole d being under the stock rail already fixed.

Some of the check-rail chairs obtainable do not space the check rail and stock rail at the correct distance apart, as laid down in Table IV. If such are employed the standards must be modified to suit. For instance, the spring-steel check rail chairs (Fig. 105) give a spacing of $\frac{5}{32}$. In No. 0

gauge this is excessive, but in Nos. 1, 2 and 3 gauges causes no trouble whatever.

No. 00 Gauge "Table" Railways.—This standard gauge has been recently introduced by the writer at the instance of Mr. W. J. Bassett Lowke to provide for those who are limited in space to that of an ordinary dining-room table. Clockwork and electric locomotives are supplied. The actual gauge is 16 mm. (⅝ in.) and the scale is 4 mm. to the foot. The sections of the track are stamped out in one piece of sheet metal and painted to represent sleepers and ballast. Points and crossings are available, of course, as finished parts only. Strip brass soldered to strip metal sleepers has been used by several amateurs for model railways of this gauge, one firm having already commenced to produce hand-made scale models of locomotives and wagons to suit this track material.

CHAPTER VII

Laying Model Track

In laying small-gauge tracks there are two conditions which, to some extent, govern the methods to be adopted. If, as in the one case, the track is to be made up in such a form that it can be transported or used like the ordinary toy-shop tinplate track in sections laid down on the floor, then the sleepers must be nailed or pinned down on to the longitudinal strips of wood. This system introduces the term "laid on battens," which is a feature of the model dealers' catalogues. They must support the track for transhipment, and the sections are laid in ingenious jigs and frames so that the pieces shall all be alike and will lift out complete when the parts are spiked together. Except that the battens allow the sections to be handled after assembly, there is no merit in their use. If a permanent model is to be built the sleepers can be pinned down to the substructure direct. This substructure may be boards laid on frames, or the frame members themselves in the case of a raised-up outdoor line, for which the use of boards would introduce warping troubles, and are best omitted.

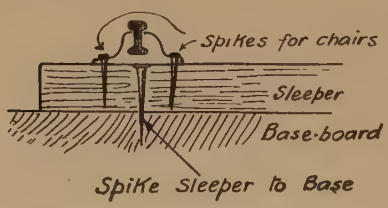


Fig. 126.—Driving Spikes in Chairs and Sleepers

For an indoor track on a boarded frame the sleepers may be of any thickness—or thinness, rather. The spaces between them are usually filled in with granite chip or other

loose ballast, which can be removed when it gets too dirty. The sleepers should be pinned down with fine "panel pins," these spikes being driven directly under the centre of the

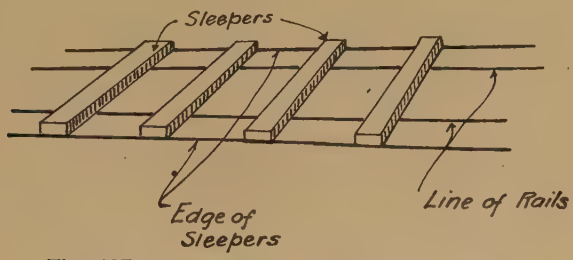


Fig. 127.—Marking-out for Rails and Sleepers

rail and chain. In this position they will not interfere with the chair spikes (see Fig. 126).

Marking Out Track.—The preparatory work consists of marking four lines (Fig. 127) in blacklead to represent the outer edge of the sleepers and the gauge of the railway. For spacing sleepers no marking is necessary. A jig (Fig. 128) can easily be made in wood, which will accomplish the work automatically.

One or two of these appliances with different spacing (one larger and one smaller than the normal will do) may be employed to allow for variations. One sleeper is first placed squarely with the line of railway, and others follow it. Curves are best marked out with a trammel. A simple trammel is a lath of wood with a hole for a pencil at one end, and a nail which may be placed in either one of four holes at the other end. A more elaborate trammel is shown in Fig. 130. Here the pencil is fixed in a

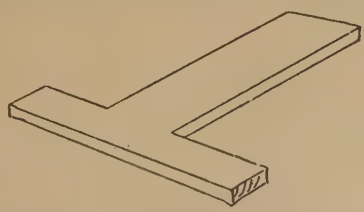


Fig. 128.—Jig for Spacing Sleepers

slide, and the various spacings would be marked out on the top of the trammel as required.

Bending Rails.—Hollow rails of tinplate or brass sheet may be bent between the thumb and fingers, drawing the rail through the hands with a sweeping action. It will require a little practice to get the best results. As a rule,

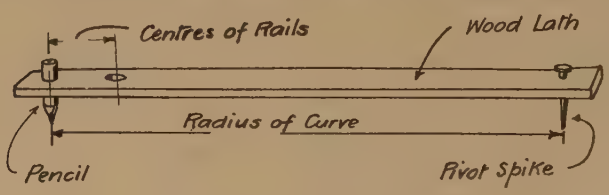


Fig. 129.—A Simple Trammel

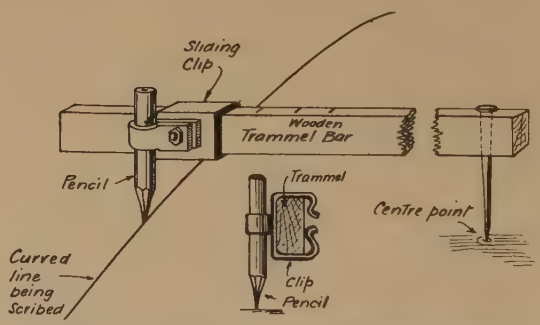


Fig. 130.—Trammel for Marking-out Tracks

the ends will not be properly curved; the centre portion will be found easy to shape. It is the ends that matter most, and instead of producing a rail as shown in Fig. 131 with the ends straight, the exact curvature of the middle part may be left to chance, the extremities being correct. This will tend to prevent what is called a dog-legged curve (Fig. 133) in the finished track. Before a length of curved

rail is passed out for laying down, the eye should be applied to the end to observe if there are any bad kinks in it. These should be avoided or removed if present.

Solid rails can be bent in the partly-open jaws of a vice, or by hand, as must be done in the case of the more delicate hollow rail. The curving of the ends is, however, just as important, even more so, as a solid rail requires greater force to bend it.

To test the accuracy of a curved rail it may be laid against a template of wood, or to a curved line drawn on paper, or a piece of planed wood. For bending solid rails a device, such as shown in Fig. 134, may be fitted to the work-bench. The amount of opening of the jaws will have to be proportionate to the minimum curve required and the size of the rail. The bending is done by a series of side movements at short intervals in the length of the piece of rail, as indicated in Fig. 135.

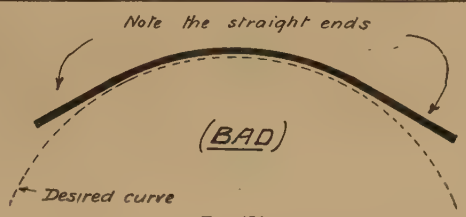


Fig. 131

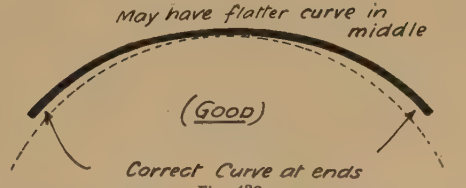


Fig. 132

Figs. 131 and 132.—Diagram showing Good and Bad Methods of Bending Rails

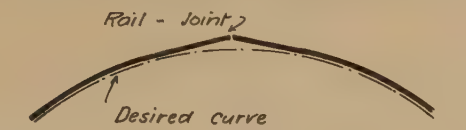


Fig. 133.—A Dog-legged Curve

Laying Rails in Jigs.—Where the commercial method

of laying model rails with wooden sleepers on battens is required to be followed, curves may be laid in wooden jigs, which hold the sleepers and battens in their correct relative positions while they are being nailed together. The chairs are fixed to the rails, properly spaced, and then laid on the sleepers. For straight track, rail holders, which fold over the jig, may be arranged to grip the rails during the spiking operations. For curved sections of large radius, such a holding device would form part of a trammel (see Fig. 136). In this the jaw or gauge-plate holds the rail at the correct radius. Where the jig is permanent, and is a workshop fixture, for every "curve jig" two or three trammels are used. The gauge-plates would then be made with two jaws for holding both rails at the correct gauge.

Points and crossings which have to be repeated in large quantities are laid in the same way, with hinged rods, like the trammel rod shown, having plate-jaws for holding the rails in position during the spiking operations.

Laying Small Model Rail. — Presuming that the sleepers are fixed down to the substructure of the line, the outer rail of the curved sections and the rail which meets it on straight portions should be laid first. In the usual procedure, anything from 3 ft. to 6 ft. of track may be completed at a time, but in every case one rail should be laid, trued up, and finally secured before the laying of the opposite rail is attempted. Each piece of rail should be fixed at each end (assuming it is on a straight portion of the track), firmly and permanently at one end and loosely at the other. Intermediate chairs should then be fixed, not absolutely finally, starting at the middle and then the quarter distances. When the line is tamped straight, hammer down all spikes tightly. With the hollow "Lowko" type of rail care must be taken not to strike the rail and damage the

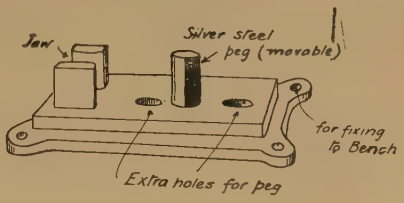


Fig. 134.—Fixture for Bending Rails

Fig. 135.—Bending the Rail

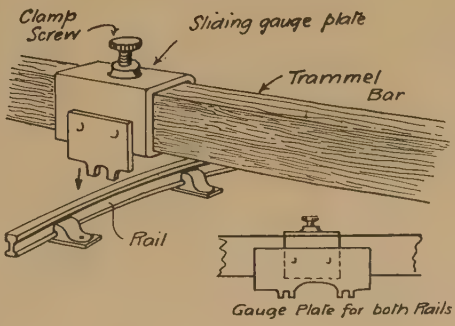


Fig. 136.—Restraining Trammel for Laying Curves on Battens in a Jig

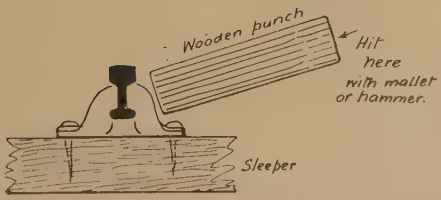


Fig. 137.—Wood Punch

hollow top. If a part requires slewing to get the rail dead straight, then the chair only should be struck sideways, *using a block of soft wood*, shaped like a metal punch but of more robust dimensions, between the chair and the hammer. Even with a solid rail it is better to push the rail over by striking the chair than by hitting the rail with a hammer or punch. Until a length of rail is aligned up it is better not to finally hammer down the chair spikes.

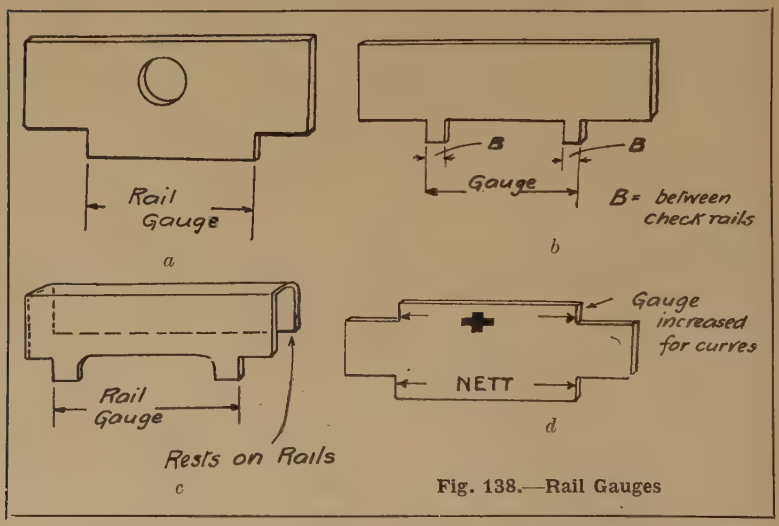


Fig. 138.—Rail Gauges

When the rail on one side of the track is satisfactorily laid the opposite rail may be fixed down, using some form of "gauge." A few of these easily-made appliances are shown in Fig. 138.

For points and crossings the lengths of rail properly shaped and fitted with the necessary special chairs should be prepared from the drawings before the work of laying is commenced. Point parts are, however, sold complete by several firms who specialise in model-railway work.

Laying Small Keyed Chair Permanent Way.—In the instructions for laying small model permanent way with keyed chairs Messrs. Bassett-Lowke recommend the use of a simple jig for spacing the chairs on the rails. This consists of a piece of board with a wooden stop at the end and a number of brass strips equally spaced at the chosen

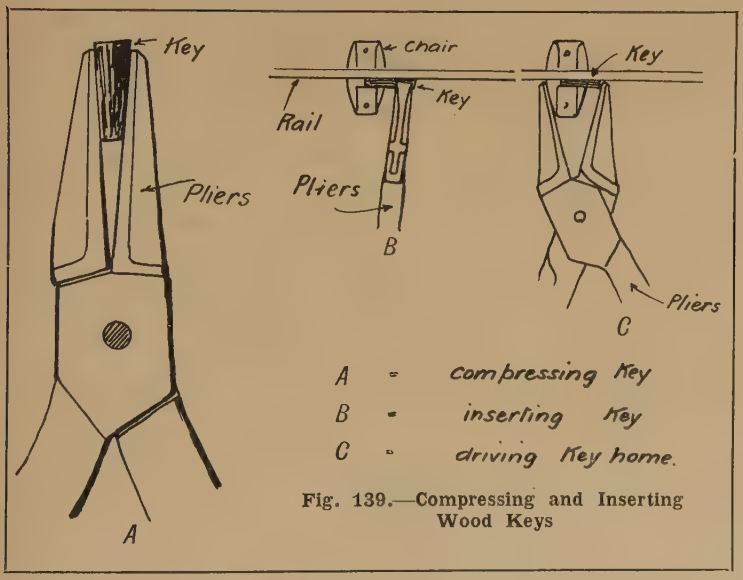


Fig. 139.—Compressing and Inserting Wood Keys

intervals to fix the position of the chairs. It is not usual to lay such track by first putting the chairs on to the sleepers, as is done in real railway practice and in the case of larger outdoor passenger-carrying models.

The other tools required in laying this track consist of a small cross-pened hammer, a pair of 4-in. or 5-in. flat-nosed pliers, a hollow punch, a small flat file, and a hack-saw with a fine-tooth blade. The chairs should be placed fairly close together. It is false economy to use only four or

five sleepers per 18-in. length of track. A spacing of $1\frac{1}{2}$ in. between the sleepers is recommended for the smaller material used for No. 0 to $2\frac{1}{2}$-in. gauge railways, and $2\frac{1}{2}$-in. to $2\frac{5}{8}$ in. apart for the larger-scale tracks of $3\frac{1}{4}$-in. and $3\frac{1}{2}$-in. gauge respectively (see Fig. 128).

A jig for spacing the sleepers is also recommended, and the spikes holding down the track to the base should be driven as indicated in Fig. 126. To handle the wooden keys satisfactorily pliers are necessary. The key is first compressed, as shown at A in Fig. 139. This makes it slightly wedge-shaped, and it is then held as illustrated at B, entered between the rail and the chair as at C, and finally driven home by the manipulation of the pliers, illustrated in the sketch at D. The usual procedure of first laying a rail on one side of the track and then the opposite rail is adopted with these materials. A gauge (the "Simplex" appliance shown in Fig. 140) is employed to preserve the gauge of the line and for automatically obtaining the desirable slight addition to the rail gauge on curved portions of the line. Fig. 141 shows how this is accomplished.

It is also recommended that super-elevation, where it is necessary, should be obtained by fitting a thin strip between the sleepers and the substructure of the model railway. At each end this strip may be thinned down to zero.

For knocking on fish-plates and other adjustments to the track (excepting driving the spikes), a wooden or hide mallet should be used in preference to a steel hammer. The latter would damage the softer metal used in the track material.

Tinplate Points. — The one important difference in the construction of tinplate points and the copying of the orthodox system adopted where all other model track material is used, is the absence of frogs and their attendant wing and check rails. An arrangement of switch rails,

called by the author the "positive" system of points, is employed, in which the two tongues are mounted together and pivoted at or near the centre on a suitable sleeper (see Figs. 142 and 143). The switch rail has, therefore, a duplex action. When the tongue leaves the stock rail the other end moves away from the apex of the rails, which cross at the point where a frog would normally be used. The other switch rail takes its place on the completion of the move-

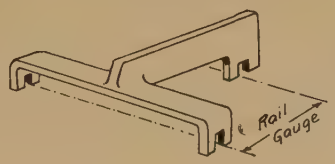


Fig. 140.—Simplex Gauge

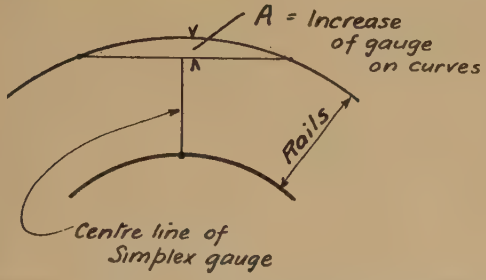


Fig. 141.—Diagram Showing use of Simplex Gauge

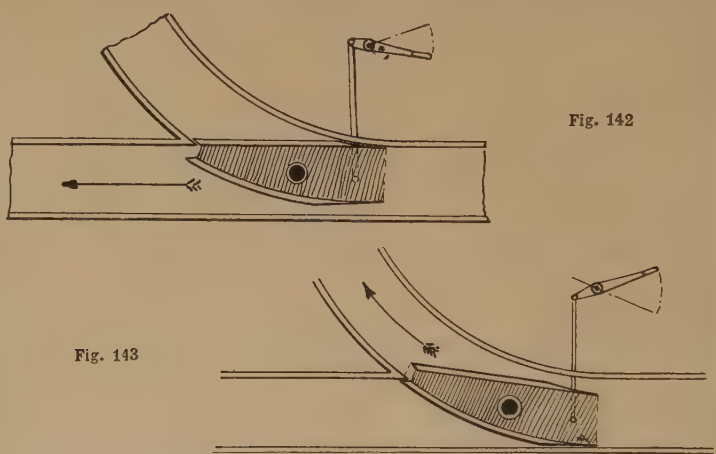
ment. When well made these points provide a continuity of rail surface, a scheme which has much to recommend it. In full-size practice the frog of a rail-crossing is recognised to be a necessary evil, and utmost care is observed to obtain soundness and accuracy at this part of a set of points. In America there is a trend towards the introduction of moving frogs to eliminate the gap, and several examples of this construction are to be found on British railways.

In some cases crossing of the two rails is not formed with a regular apex. The rails meet end to end, as illus-

trated in the "stub" points (Fig. 144). There is not much to choose between the two systems.

Stub Points.—Points of this kind (Fig. 144) are of an obsolete pattern used in the early days of full-size railways. Beginners may find them less troublesome to make than the usual type with tapered switch tongues.

Switch Tongues and Cranked Rails.—However fine



Figs. 142 and 143.—Positive Points as used in Tinplate Tracks, shown in two Positions

one files the switch tongues of a set of points there is always a certain amount of bluntness apparent when the switch rail is laid against the stock rail. As indicated at A (Fig. 145) this blunt edge is distinctly felt by the flange of the oncoming wheel. The feature is one which is not lessened in a model, and the practice of cranking the stock rail, adopted by several railway companies, may be copied by the model maker with advantage. The stock may have the inner face filed back in a vertical plane to receive the

tongue, as shown in Fig. 146, or the rail can be cranked, as in Fig. 147. If this is done it is important that the displacement of the stock rail should be local. The portion A should exactly follow the line B, as shown by the projected dotted line, which is drawn in the diagram through the cranked portion of the rail. If the stock rail is curved the same effect should be obtained—the true radius must be continued after the cranked portion has ended.

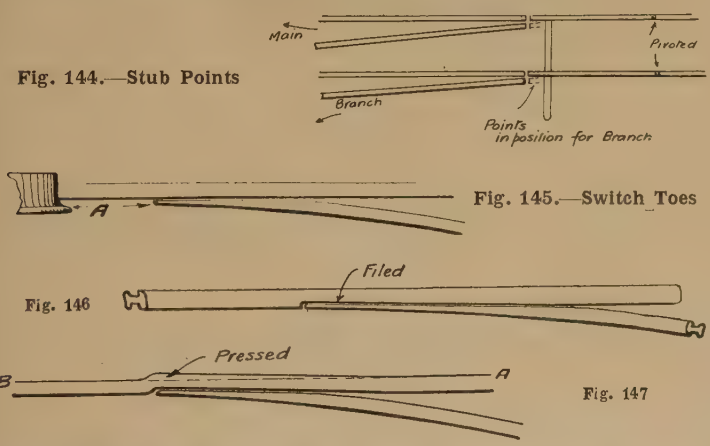


Fig. 144.—Stub Points

Fig. 145.—Switch Toes

Fig. 146

Fig. 147

Figs. 146 and 147.—Cranked Stock Rails made by Filing or Pressing

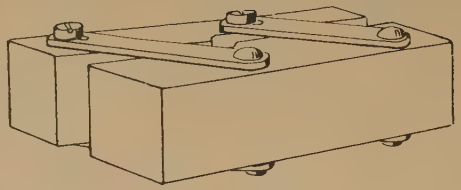
With a solid rail this cranking is very easily done in the vice with two pieces of $\frac{1}{16}$-in. steel plate suitably interposed. A more dependable device is an arrangement of two linked dies made out of pieces of rectangular mild-steel, as illustrated in Fig. 148. The links are optional fitments, and serve to keep the parts together. On one side the joints should be made with dotted holes to give a free movement. There are, of course, many other methods of linking the two die-blocks together. Fig. 149 shows the dies in use,

the necessary power being provided by a bench vice. In cranking a stock rail the position of the "set" should be carefully positioned, so that the switch rail will fit up closely to the shoulder.

The Connection of Point Rod to Switch.—One of the most troublesome items in the making of points is the devising of a satisfactory connection between the switch rails and the point rodding. In real practice it is possible to provide fastenings which will give the necessary flexibility between the rods and the two tongues. Where the tinplate system of pivoting the points is employed the two switch rails may be joined together rigidly, and in this case the rod from the lever may be pivoted to any convenient part of the plate which connects the two components. The same applies to points which are made with the switch rails rigidly connected together right up to the frogs, where they are suitably pivoted and move as one unit. When this construction is adopted, the cross-bars which pass under the stock rails and prevent the tongues rising may be soldered to the switch tongues, as at x (Fig. 150). Otherwise the cross member will have to be provided with a cleat, which is loosely riveted to the bar so that it will swivel the slight amount necessary to obtain a perfectly easy movement. The cleat or angle may be riveted and soldered to the switch tongue, as at Y (Fig. 150).

Another method is to shoulder round cross-bars (two would be used in larger work, and one only connected to the lever), and loosely to rivet them over on the inside. The riveted head formed is housed by the recess at the web of the stock rail. The point-rod connection is then made to the centre of one of the cross-bars, as illustrated in Fig. 151.

"Millbro" Point Rod Fixing.—One of the most suc-



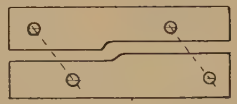


Fig. 148.—Die for Cranking Stock Rails

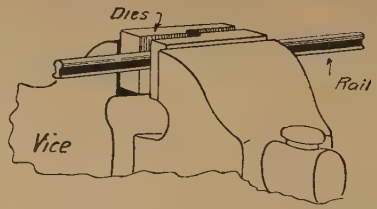


Fig. 149.—Using the Cranking Tool

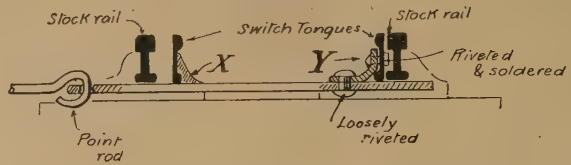


Fig. 150.—Fixing Point Rods to Switch Rails

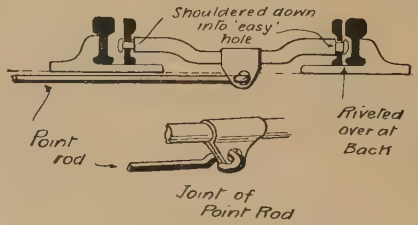


Fig. 151.—Shouldered and Riveted-on Point Rod

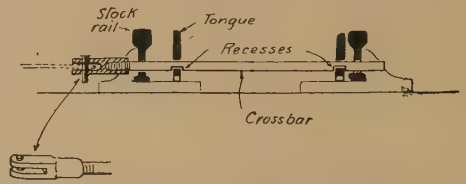


Fig. 152.—" Millbro " Semi-tight Point Rod Fixing

cessful devices is that worked out by the author for Messrs. Mills Bros. They use a steel rail (see Fig. 103, Chapter VI), which is most suitable for $1\frac{3}{4}$-in. to $2\frac{1}{2}$-in. gauge railways. The rails (both switch and stock rails) are first drilled for a cross-bar $\frac{3}{32}$ in. or $\frac{1}{8}$ in. in diameter. The cross-bar is then filed with the edge of a small flat file in two places opposite the switch rails. When fitted together the holes in the tongues are pushed up into the recesses in the bar with a punch, as shown in Fig. 154. This should not be done so violently that the bar is gripped by the rail. A

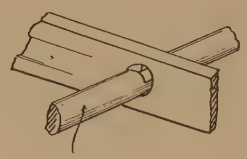


Fig. 153

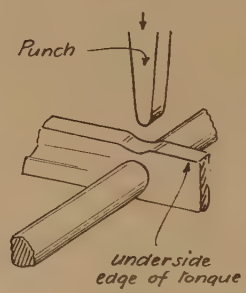


Fig. 154

Figs. 153 and 154.—Fixing the "Millbro" Point Rods

large degree of looseness is essential to the arrangement. The connection to the points may be by a screwed eye at the end, as shown, or a fixing like that illustrated in Fig. 151.

Points Pivoted at the Frog.—Possibly one of the most satisfactory arrangements for working points by any power scheme is to make them as illustrated in Figs. 155 to 158. The switch rails are joined together into one unit, which swings about a pivot situated at the apex of the crossing. Such points will, if properly made, also work "trailing." Even when quite a light truck is propelled through the adversely set points the vehicle will not derail (if it is not locked

by the point lever), but will open the tongues and let the flanges pass safely through. This is a minor advantage, as most of the levers used in model work are of the non-reversible type and firmly hold the points against any lateral pressure on the switch blades. Where "power signalling" is employed, such points should move with the least possible effort.

As will be seen from the diagrams the wing rails do not move to an appreciable extent, and therefore any difference in the spacing of the adjacent wing rails is not noticed either by the train or by the observer. The train is not running over the part of the frog which has its wing rail a little closer to the apex rail of the V than it should do. Furthermore, half the error may be eliminated by spreading the wing rails open to the

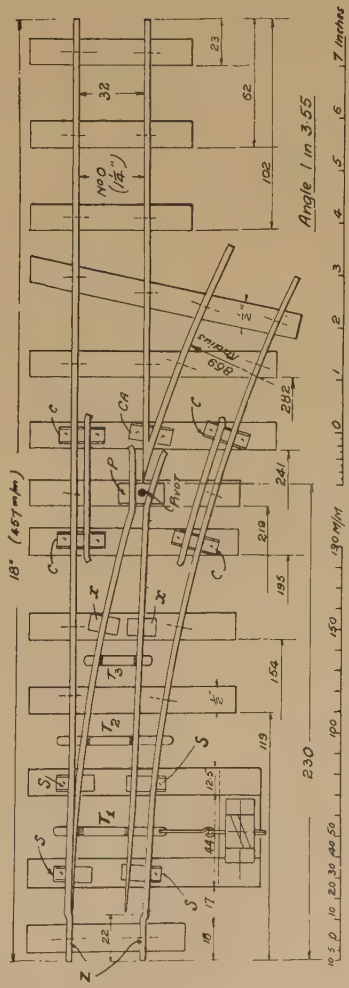


Fig. 155.—No. 0-gauge Points with Pivoted Frog

same amount. The error is then so small as to be almost immeasurable.

The only other drawback is, perhaps, a more serious one. It is that solder must be relied on to hold the parts together. This arrangement is satisfactory in Nos. 0 and 1 gauges, but cannot be termed good practice in a $2\frac{1}{2}$-in gauge line, which would, no doubt, be laid out of doors and have to withstand comparatively heavy loads travelling at high speeds. The length of the point-switch unit in $2\frac{1}{2}$-in. gauge is considerable, and therefore the scheme, in the form illustrated, may be ruled out as inapplicable to any but the two smaller standard gauges.

Fig. 155 illustrates a pivoted point with a 5-ft. $8\frac{1}{2}$-in. diameter R.H. turnout, giving a frog angle of 1 in 3.55. Crank-stock rails are used, and the rail chosen is the $\frac{1}{2}$-in. scale section solid-steel rail, with the spring-steel chairs, which comprise the ordinary slide and check rail patterns, and spring-steel fish-plates. The pivot plate P (Fig. 156) may be made of 20 S.W.G. tinned-steel plate or, if the wing rails are brazed at this point, ordinary mild-steel plate may be employed. To lift the rail to the correct height and to reduce friction in its movement over the wooden sleeper, it may be pressed out as shown in Fig. 157, or used flat with a washer underneath it, as shown in Fig. 156. In any case, this question of level must be attended to, otherwise the wheels will bump heavily at the crossing. At XX two ordinary chairs are slipped on to the rail, but not spiked down. The chairs give some support and tend to maintain the point rails at the correct height above the level of the sleepers. Also they improve the appearance of the switch. At T_1, T_2 and T_3 strips of metal $\frac{3}{16}$ in. by $\frac{1}{16}$ in. are soldered to the blades, a good fillet of solder being arranged on the inside of the rail (see Fig. 158) only. Two of these cross

strips are sufficiently long to prevent the tongues of the switch from rising up above the normal level. The ends of the switches are supported by the slide chairs (s). Two check-rail chairs c on each side are sufficient, although by using three, if one breaks there will be no displacement of the rails at this point. The check-rail chair (C A) has one side broken off (see Fig. 159). This arrangement will be found available in holding down rails which converge at

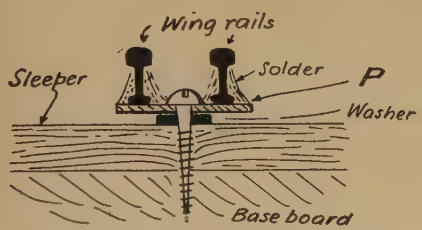


Fig. 156.—Cross Section of Pivot

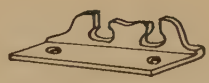


Fig. 159.—Altering Check-rail Chairs for use at Frog Apex

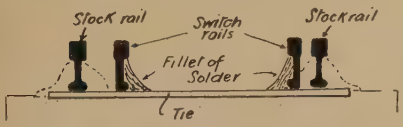


Fig. 158.—Permanent Tie Bars for Switch Rails

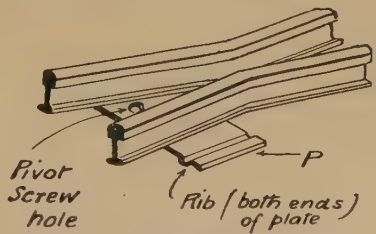


Fig. 157.—Fixing Wing Rails to Pivot Plate

an angle, and renders the use of solder at the apex quite unnecessary.

The stock rails are cranked. Where this is done it is important that the end portions z should be quite parallel and in line with the straight track. Any corrections to this end should be made before the track is finally spiked down. The position of the point lever has been shown fixed on the end of two elongated sleepers. It may be on either side of the track, at any distance clear of passing vehicles.

Where not definitely specified by reference letters on the drawing, ordinary chairs are employed, their positions being indicated by the dotted centre lines, and as so much depends on the position of the sleepers these have been definitely dimensioned in millimetres. The sleeper at an angle would only be used if the branch line were continued on the curve or at a tangent to it. Fig. 160 shows an arrangement of the sleepers for a turn-out lying parallel to the main line.

No. 1 Gauge Crossover.—This crossover is designed to suit the so-called "½-in. scale" steel rail and the spring-steel chairs now marketed. Except for the use of the altered check-rail chairs at the frogs (marked CA in Fig. 161), the crossover can be laid with any other bull-headed rail for

Fig. 160.—Position of Sleepers for Parallel Turn-out

which check rail C and slide chairs S are supplied. If the switch rails are cut at *f* and joined by a fish-plate it is necessary to adopt some form of point-rodding which will retain the tongues in place longitudinally. Otherwise they would creep out longitudinally with the jar of passing trains. The scheme shown by Figs. 153 and 154 is one of the best forms of fixing in such a case. All the four rails are drilled for one rod, and nothing can move once the chairs are spiked down. In fitting up points made in this way it must be noticed that to assemble the parts one of the stock rails, preferably the moving one, must not be fixed down permanently at the entering end of the points until the switch rails, complete with the cross-rod, are put into place.

In laying such a crossover one of the outside straight

stock rails may be laid down with its check rail, and lined up true. The apex of the frog is then prepared (if all parts are not actually made before the assembling is commenced) and fixed, the straight rail being spiked down accurately to the standard-rail gauge. As the wing rail and the check on the diagonal-stock are in one piece, the check chairs must be put into place on the two rails. For the moment the ends of both may be left free, so long as the apex portion is fixed down, and the maker immediately proceeds to spike down the remainder of the straight road to the heel of the switch at *f*. Carefully measuring its position, the outer straight rail of the other road may be fixed down, truly parallel and straight,

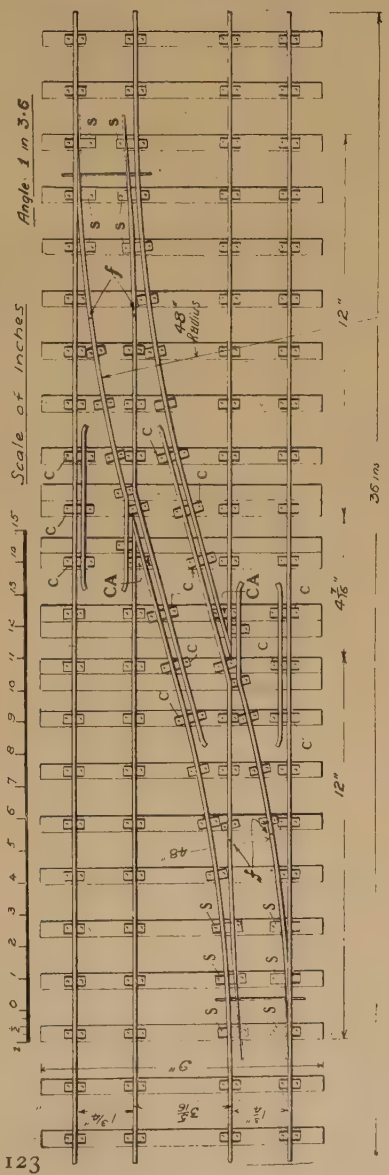


Fig. 161.—Crossover for No. 1-gauge Line

the remainder of the work taking the sequence described above. The last thing to spike down is the inner curved stock rails at the two entrances to the points.

It should be noted that as both the wing and check rails are bent outwards at the ends, if the section is left square, there may be difficulty in threading the rails on to the spring check-chairs. The author gets over the trouble by filing the bottom bulb and web to a straight face on the bent-out side. The diagram (Fig. 163) attempts to show this in perspective and in plan. Slide-chairs are excellent

Fig. 162.—Photographic Illustration of Crossover

fittings, and although in small work they often do no more than prevent the road spreading, they support the tongue, and if filed smooth on their sliding surfaces make a wonderful difference to the "sweet" working of the points. A substitute for slide-chairs is a piece of strip metal stretching across from rail to rail. This should be drilled for spikes and soft soldered to the rails with a good fillet on the outside, the inside being quite free of solder.

A Double Junction. — The accompanying design (Figs. 167 and 168) for a No. 0-gauge double-junction (R.H.) was prepared with three things in view: (*a*) the employment of standard point parts for both switches; (*b*) the

use of the same radius for the two turn-outs; and (*c*) the convenient arrangement of point rodding.

If a double road is used the inner and outer lines must

Fig. 163.—Forming Ends of Check and Wing Rails for Slide-on Chairs

on curves be of different radii. This introduces minor troubles when it comes to points, and, therefore, the setting detailed in Fig. 169 is suggested as a suitable way out. At the entrance to the two curves (i.e. the points) lines are struck from T G, which are placed about 1½ in. (36 m/m)

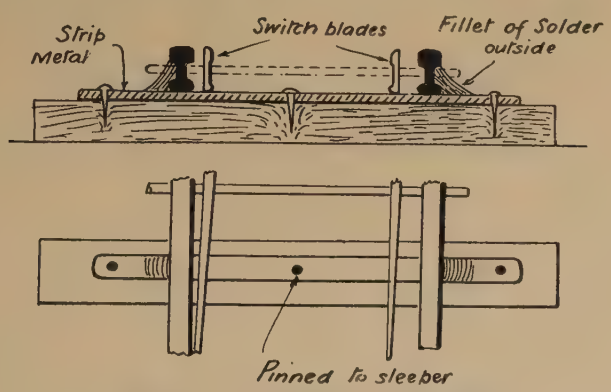


Fig. 164.—A Substitute for Slide Chairs

apart, the radius of both being the same as that of the No. 0 gauge points illustrated in Fig. 155. When the roads are clear of the crossing the inner track may be concentric.

Setting Out Curves.—In laying out the curves of even the smallest model railway it is highly desirable that the entrances to all curved portions of the track should be of elliptical form. To set out such an entrance in a truly scientific manner and to follow out the said marking, is difficult in practice, so much of the work is done by eye, i.e.

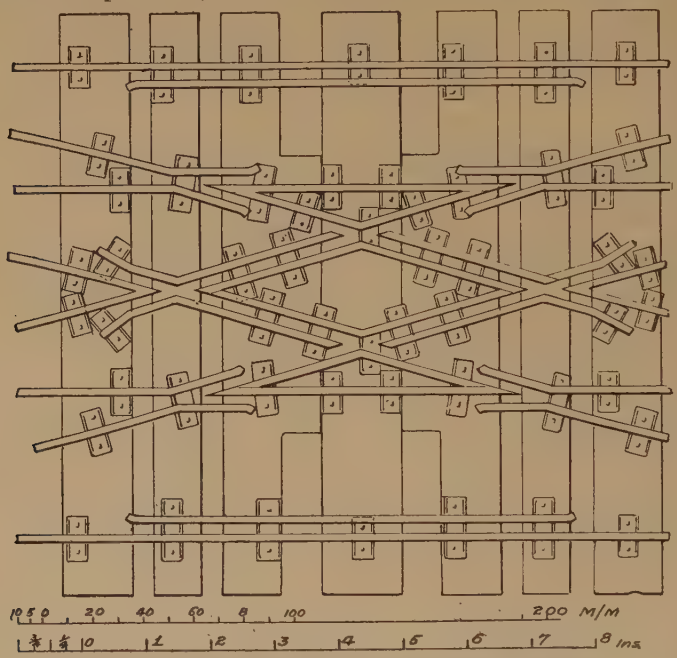


Fig. 165.—Design for No. 1-gauge Scissors Crossover

by looking along a curve close to the surface of the rails.

The usual case which presents itself in a model is the laying of the corner curves of a track in a rectangular room. The ordinary and obvious course in setting out a curved section is to settle on the largest radius permissible, and to make it meet both the straight portions of the railway as in

Fig. 170. But this does not give the best results in actual running, especially if the particular radius chosen approaches the minimum, as usually happens in a model indoor line. The locomotives and trains strike such curves violently. Further, the curve will require the maximum super-elevation throughout its whole length, which means that this canting of the outer rail must commence on the straight portion. Such a proceeding would, of course, interfere with the fitting of points and crossings close up to the curve, and if they are necessary super-elevation may have to be dispensed with or modified.

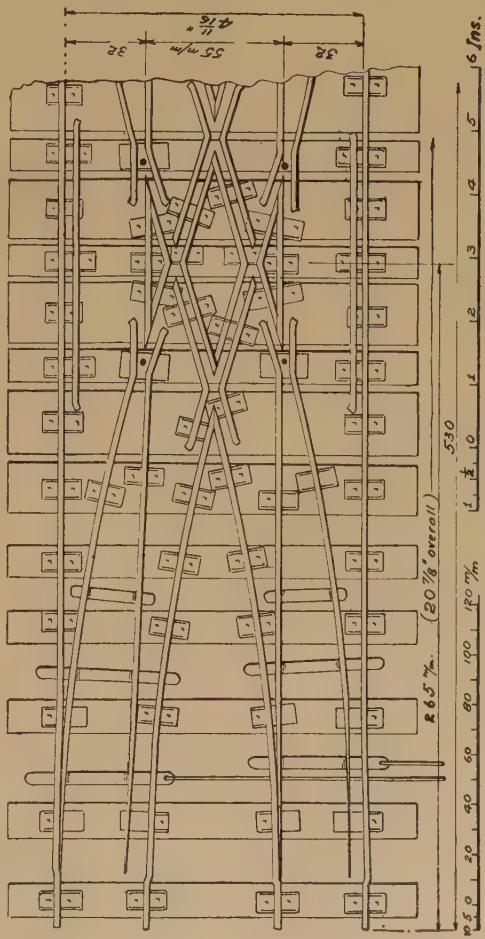


Fig. 166.—Scissors Crossing in No. 0-gauge

To get over the trouble it is better to compromise in the matter of radius. Supposing that the minimum radius of a given line is 4 ft. and that 5 ft. would be adopted for fast lines. Instead of filling a corner with a curve of 5-ft. radius, set out tangentially to the straight roads, as illustrated at A (Fig. 171), the author would recommend the use of a 4-ft. 6-in. radius curve with 6-ft. radius entrances, as shown at B in the same illustration. The curve will only encroach a few more inches on to the straight tracks.

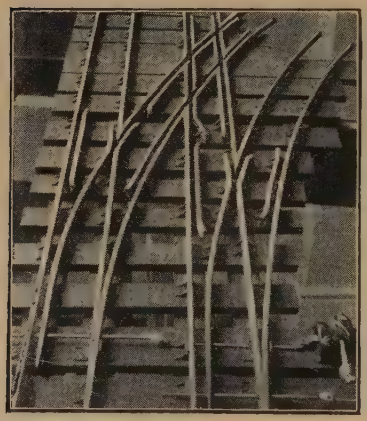


Fig. 167.—No. 0-gauge Double Junction

As already mentioned, it is somewhat difficult to work exactly to such setting-out in laying track, and, therefore, the author has frequently adopted a simpler plan. Where a 5-ft. radius would be used under normal circumstances, a lesser radius—by half the rail gauge—is marked out. This is done from the same centre as that from which the 5-ft. radius would be struck out if it were laid truly tangential to the straight tracks, as shown in Fig. 172. In laying the rails the straight lines are finally trued up and fixed down as far as P P, and the curve as far as Q Q. The portion between these points—which may actually be in their approximate positions and not omitted as shown in the diagram—would be fixed down by eye, the natural transition from the straight line to the curve being easily obtainable in this way. When the work is completed the precise

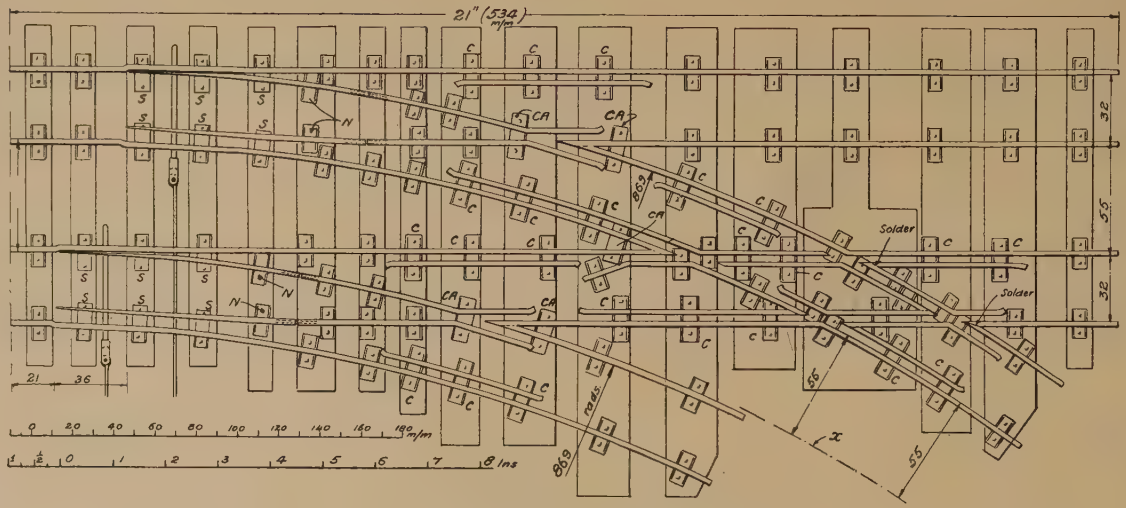


Fig. 168.—A Double Junction in No. 0-gauge

point where the straight road ends and the curved portion commences should be imperceptible. This result is very desirable, as trains traversing such a line will be diverted gradually and without shock.

Where two curves would in ordinary circumstances be

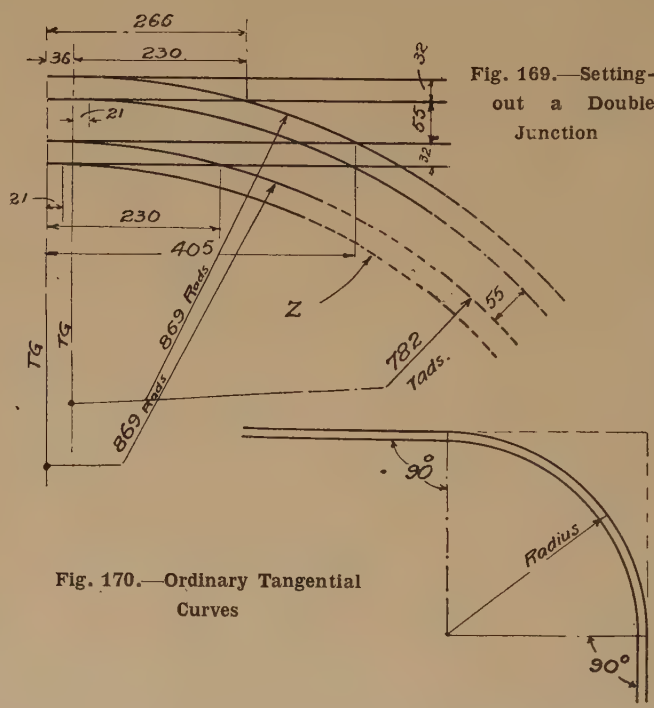


Fig. 169.—Setting-out a Double Junction

Fig. 170.—Ordinary Tangential Curves

joined by a short piece of straight track (as C, Fig. 173), it will be found most satisfactory to connect them with a curve of large radius, giving the egg-shaped end to the track indicated at D. This, of course, presumes that a crossover or a set of points is not required on this part of the track,

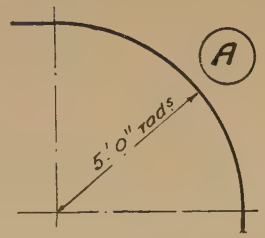
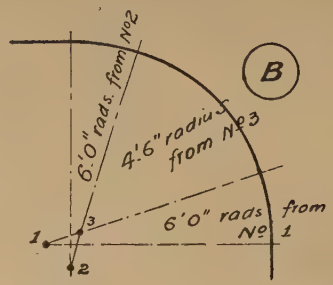


Fig. 171



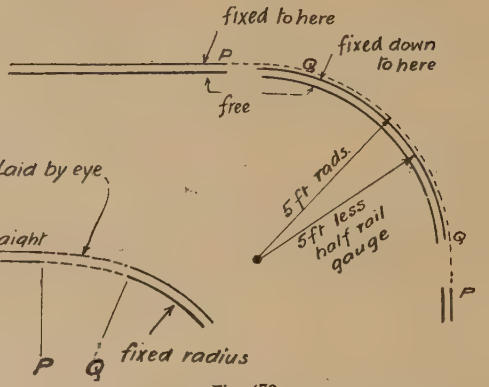


Fig. 172

Figs. 171 and 172.—Setting-out and Laying a Corner Curve for Nominal 5-foot Radius

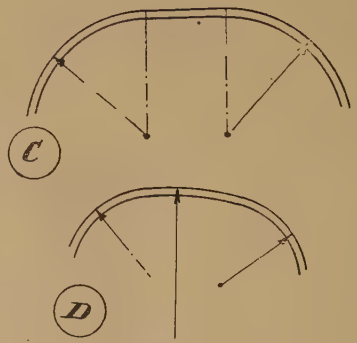


Fig. 173.—Joining-up Two Curves

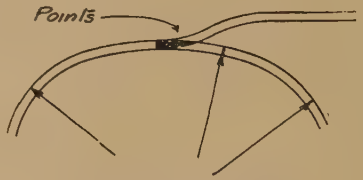


Fig. 174.—Position of Points

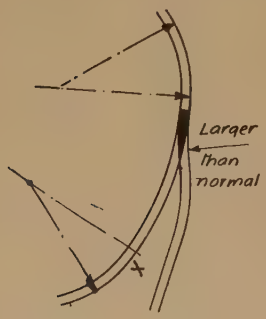


Fig. 175.—Three-radii Curves

although if the turn-out is outside the circle there is no objection to points being arranged on the largest radius, as indicated in Fig. 174. Points which turn inside a circle are not so satisfactory as those arranged on diverging curves or those which branch off from straight tracks.

In setting out three radii curves it will be noticed that the intersection of curves of two radii must fall on a line which if produced cuts both the centres of the larger and smaller curves. In Fig. 175 the two curves join at x, therefore a line drawn from this point passes through the centre of the smaller radius on its way to the centre of the larger one.

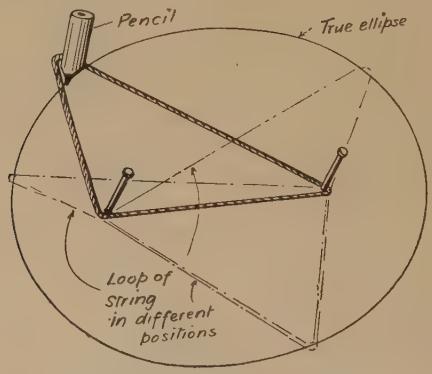


Fig. 176.—Drawing an Ellipse

Fig. 176 shows a method of marking out a true ellipse with a piece of string or cord formed into a loop.

Cast Frogs.—These are sometimes employed for out-

door passenger-carrying railways, and save considerable trouble where a large number of points of one kind are necessary. The design of the fastenings to the ends and the adjacent rails may require modification to suit different rail sections. As shown in Fig. 177 the ordinary bull-headed rail is employed. Cast-steel or malleable-iron is to be preferred to ordinary cast-iron for these frogs.

Outdoor Rail Laying.—Where a keyed and chaired passenger-carrying road is being laid out of doors, the procedure adopted on full-size British railways should be adopted—viz. all chairs should be fixed to sleepers beforehand. This must be done within a close limit of accuracy, those that accidentally come out to a wider gauge than the standard being set aside for use on curves. The formation

Fig. 177.—A Cast Frog

level should be prepared carefully, the surface metalled with a suitable size of material, and finally ballast of fine mesh used for packing the sleepers to an even surface. Flat-bottomed rails are fixed in position after the sleepers are laid, one rail being secured and faired up before the opposite one is spiked down to the required gauge. Sleepers must be longer and of much larger section than the scale equivalent to obtain success and a long life with the least attention.

CHAPTER VIII

Railway Signalling as Applied to Models

SIGNALLING is a feature in the construction of a model railway which arouses a considerable interest, and practically the whole of the work involved is within the scope of an amateur's equipment. No great amount of skill is necessary, and so long as the component parts are reasonably accurate in scale proportions and neatly made, the spectacular effects obtained will considerably enhance the realism of the model. Signalling on a model railway is more or less superfluous to the operation of the line, unless such is large enough to ride upon.

General Principles. — Almost all other forms of self-propelled vehicles are less dependent for safe working on a complete signalling system than those operating over a modern railway. On a railway, the fact that the vehicles are confined rigidly to the course of the track necessitates a communication between the signalmen, who command the track, and the engine-driver. In the very early days of the railways the vigilance of the driver and guards alone provided for safety, but when, in the 1850's, traffic became more congested and speeds rose to sixty miles an hour and more, visual signals by signalmen at fixed points were introduced. These included boards of various shapes and sizes, raised on posts, which were turned flat or edgeways to the driver, according to the code devised. Lastly, the now almost universal pivoted semaphore arm was evolved.

The Early Semaphore Signal.—The early signal-arm was pivoted to the top of a slotted post, the semaphore

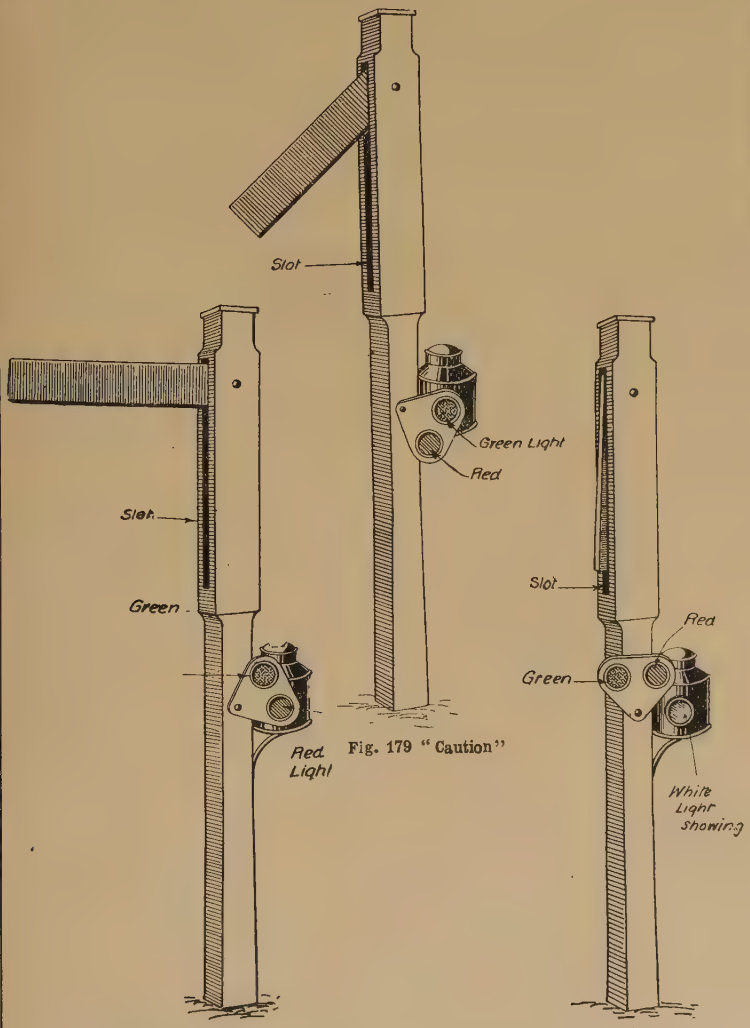


Fig. 178 "Danger"

Fig. 179 "Caution"

Fig. 180 "Line Clear"

Figs. 178 to 180.—The Old-time Three-position Semaphore

facing the driver at right-angles to the line of railway and pointing to the left on English railways. Lower down the post a lamp was fitted giving a white light, and in front of this light a "spectacle" was fixed, having a red and a green glass fixed in it. This frame was connected by suitable rods and levers to the arm and to the operating lever at the bottom of the post. Later, the arm was wired up to some adjacent spot where the signalman (or policeman, to use the early designation) could actuate several such signals.

The first semaphores showing a red light at night had three positions: "on" or "danger" (Fig. 178), "caution" (Fig. 179), when placed at an angle of 45°, and a green light and "off" (Fig. 180), "all right" or "line clear" when hanging down almost vertically and hidden in the slot in the post, the coloured spectacles being quite clear of the lens in the lamp, so that a white light showed to the driver after dark. These colours are indicated in the sketches.

The Modern Semaphore Signal.—The three-position signal, however, did not survive the introduction of the "absolute block" system of train working. Only two positions are usual nowadays, viz.: "on" or "danger," as in Fig. 181, when the arm is horizontal and a red light is showing, and "off" or "line clear," as shown in Fig. 182, when the arm is inclined and a green light is exhibited. The white light now suggests danger, as either of the spectacle glasses may have become broken.

It is with this type of signal that model makers are more or less solely concerned, although the three-position signals have been recently introduced, giving (1) "danger," (2) "line clear" for one section up to the next signal only, and (3) "line clear" for the following *two* sections. Separate signals are used for each line, and where a set of rails diverge into several ways it is the standard practice to

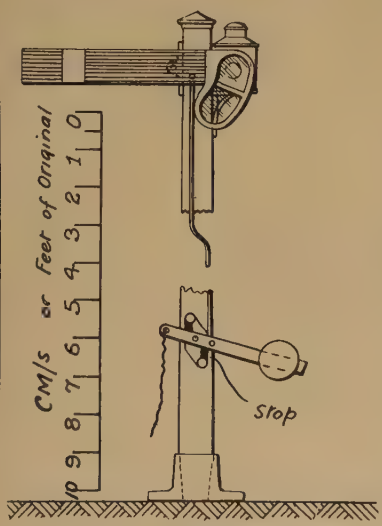


Fig. 181.—A Home Signal at "Danger"

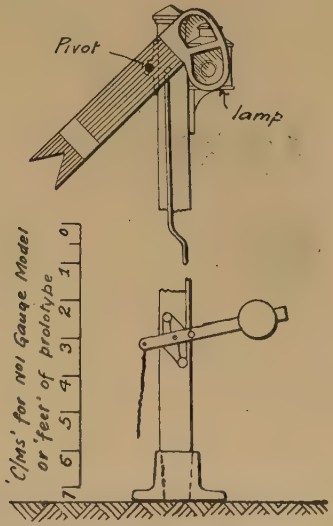


Fig. 182.—A Distant Signal in "Line Clear" Position

install a semaphore arm for each branch line. At large stations descriptive signals are used, only one arm being employed, a large board below giving the number of the platform road that at the time may be clear.

The front faces of signals are generally painted a

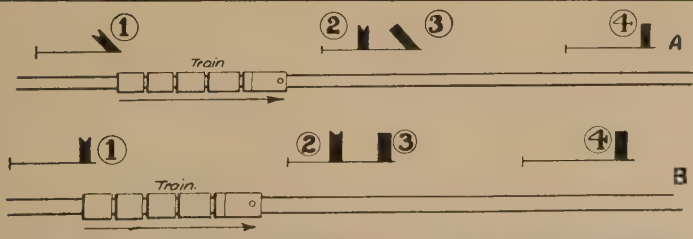


Fig. 183.—A Typical Arrangement of Distant and Home Signals

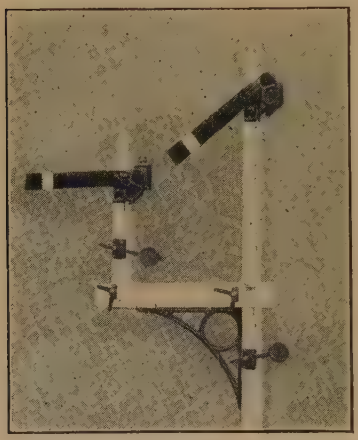


Fig. 184.—Model Bracket Signal

vermilion red, a white stripe or a white dot being arranged near the tip of the semaphore. The backs of the arms are painted white, with a black dot or stripe, as the case may be. Various types are illustrated in the diagrams and photographs of working models, Figs. 181 to 189.

Distant Signals.—In view of the fact that a locomotive driver cannot pull up his train when it is running at top speed under, at least, a quarter of a mile, the ordinary "home" or stop signal must be supplemented by a second or warning signal placed in a position nearer to the oncoming train. These are termed "distant" signals, and while they are not truly "repeater" signals, they give the driver an idea of what to expect when he arrives at the "home" signal. The distant signal has a fish-tail semaphore arm, as shown in Fig. 182. It is arranged upwards of 800 yards nearer to the approaching train than the

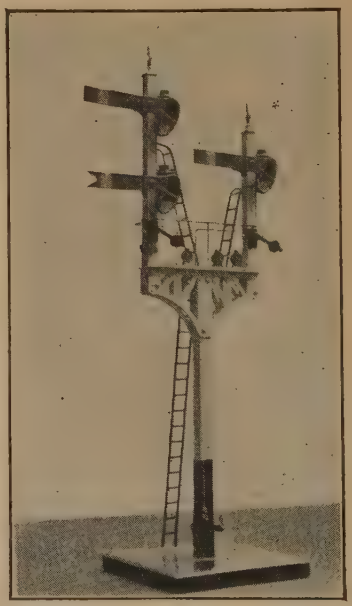


Fig. 185.—G.W.R.-type Bracket Signal

"home" signal, and, if it is showing "line clear," the enginemen know that the home signal is also in the "off" position, and that the train need not be stopped. If the "distant" signal is at danger, the driver may pass it, but must be prepared to pull up before he arrives at the "home" signal. The latter is an absolute stop signal, and on no account may be passed when at danger.

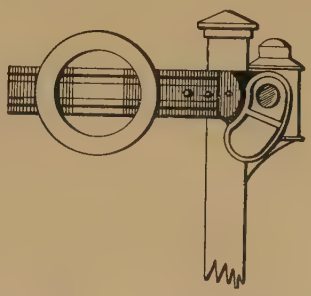


Fig. 186.—L.N.W.R. Branch Home Signal

The levers in the signal-box are also so interlocked that the distant signal can in no circumstances indicate "line clear" when the home signal is at danger. All other combinations are, however, safe.

In model work distant signals are often dispensed with, because they do not add any useful function to the system,

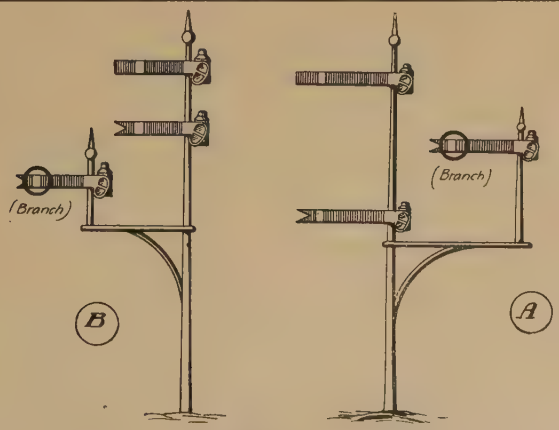


Fig. 187.—Arrangement of Bracket Signals

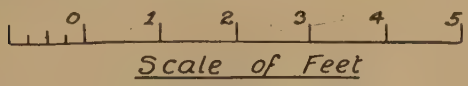
and more particularly because the sections are usually so short that there is no room for them. In real practice, where sections are relatively short the arrangement shown in Fig. 183 is adopted. In all cases the mechanical equipment, both on the posts and in the signal cabin, are such that the lower distant signal (No. 2 in diagram) can never

Fig. 188.—Group of Model Signals : Left, G.W.R. ; Right, L.N.W.R.

show "line clear" when the home signal No. 3 is at danger. Of course the home signal No. 3 may show "line clear" with No. 3 at danger. This simply means that the No. 4 home signal is at danger, and that the train must finally stop there, as will be observed on reference to diagram A (Fig. 183).

As the fish-tail of a distant signal cannot be seen at night

on some lines, means for the identification of the distant semaphore are used. The most successful of these devices is one where a reflex arrangement of the signal lamp illuminates a second fish-tailed orifice at the side of the lamp. This is shown in Fig. 190A.



Branch Line Signals.—Where a line branches into two or more sets of rails home signals are often arranged on bracketed posts, as indicated in the model signal, made up of purchased component parts, illustrated in Fig. 184. The subsidiary or branch line signal, when not otherwise determined, is usually the lower of the two, and is placed on the same side of the main line signal as the branch line diverges. Of course, both signals cannot, or should not, be showing "clear line" at the same time. These and other conflicting indications of the state of the junction are prevented by mechanical interlocking gear in the cabin and on the points. Descriptions of the application of such are given in another chapter.

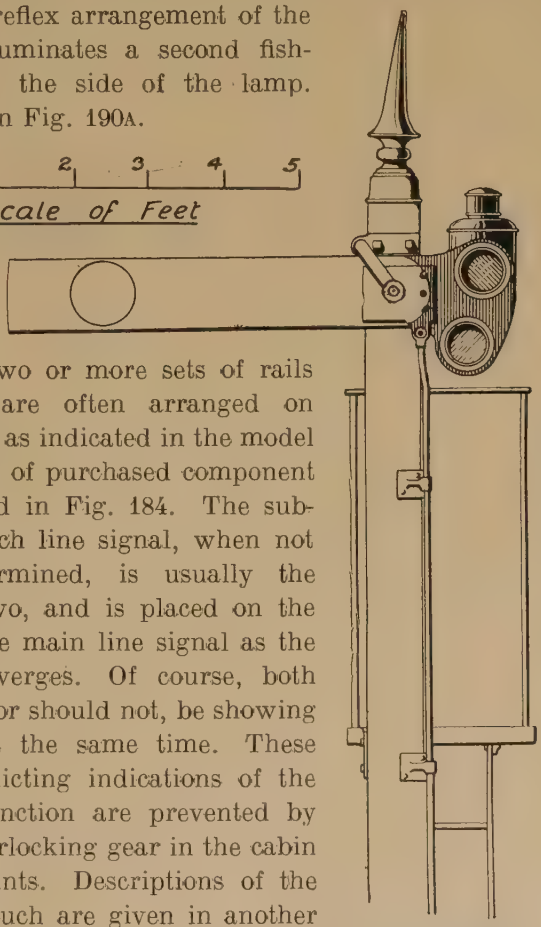


Fig. 189.—Midland-type Home Signal

Fig. 185 is a photograph of another model G.W.R. type bracket signal, in which the main line post has a distinct signal for the section beyond. Fig. 187

(A and B) represents a home signal governing a short section of main line which terminates in a junction, the distant signals showing the condition of the junction home signals. The second sketch is simply another arrangement of the same thing, the branch going off to the left instead of the right.

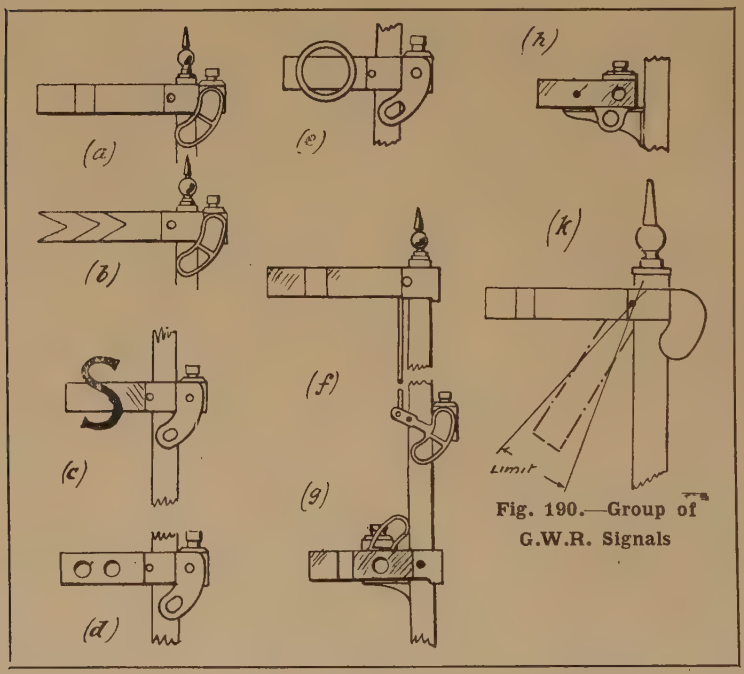


Fig. 190.—Group of G.W.R. Signals

Branch line signals are on some lines differentiated by a large ring, applied to both home and distant signals. This is illustrated by the drawing of a L.N.W.R. standard home signal (Fig. 186), such as would be applied to branch line arms, or to the whole of the signals on the subsidiary "slow" or "relief" lines on a road where there are four sets or rails, two "up" and two "down," running parallel to

each other. When a branch line has left the main, ordinary signals without the ring would be used. Some other railways paint or apply white letters to signal arms, showing the drivers to what roads they respectively apply. This is principally done at large stations and in metropolitan areas. Other railways only add the rings to siding and subsidiary signals used for shunting operations within sections such as at stations which are also controlled by main line signals.

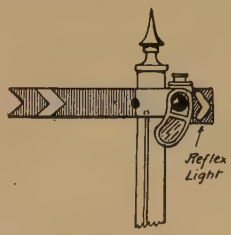


Fig. 190A.—The Coligny-Welch Distant Signal Lamp

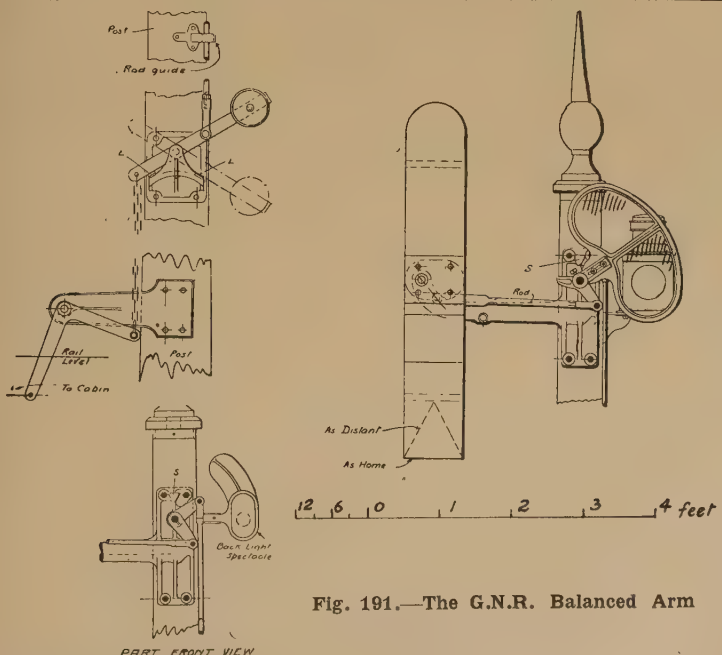


Fig. 191.—The G.N.R. Balanced Arm

Sizes and Types of Semaphore Arms and Posts.—Posts are of wood roughly 7 in. by 7 in. square at the top and tapering downwards to 12 in. square for 30-ft. to 40-ft. posts, and 14 in. by 14 in. for high signals. Bracket-signal main-posts always measure 14 in. by 14 in. at the bottom. In some cases, as on the L.S.W.R., lattice steel posts are used. The pinnacles on top vary much in design, and in some cases the posts finish in a plain square capping.

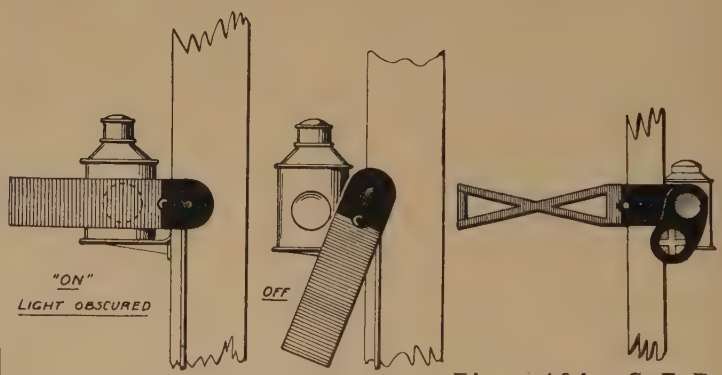


Fig. 192 Fig. 193 Fig. 194.—G.E.R. "Calling-On" Arm

Figs. 192 and 193.—L.N.W.R. "Calling-on" Arm

Arms are made of a wood such as cedar or bay wood, and vary in length from 4 ft. 6 in. to 5 ft. 6 in. from the pivot to the tip, 5ft. being a usual dimension for main line signals. Bracket-signal arms, especially those for subsidiary lines, are often made to shorter dimensions. The blades often taper outwards to the tip, being 10 in. wide at this point and 9½ in. at the pivot.

On the London and North Western line corrugated steel arms are used almost exclusively. These are shown in Figs. 186 and 197, and they project about 4 ft. 3 in. from the

face of the post, the width being 11½ in. The spectacle usually counterbalances the weight of the arm, so that should the rodding break the signal returns to the horizontal "danger" position. The rod, therefore, pushes the signal down, and is counterbalanced by a weighted lever placed near to the bottom of the post. These counterweights are shown in the series of model signals illustrated in Fig. 188.

The Midland standard signal is shown in Fig. 189, and will be seen to have many individual characteristics. On the G.N.R. the centre-balanced signal arm (Fig. 191) is used.

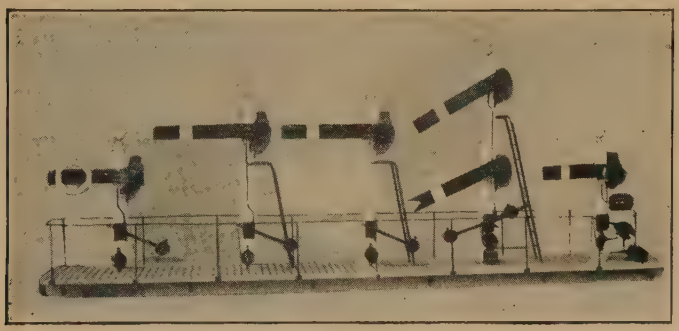


Fig. 195.—A Model Signal Gantry

This was introduced owing to an accident, in which a heavy fall of snow on the arm of an ordinary signal counterweighted it so much that it fell to the "line clear" position. This signal involves much more work in its modelling than the ordinary type. However, component parts for these signals are obtainable from at least one model dealer. All signal lamps have a small back light, which is obscured when the signal is pulled to line clear. Its use is to show the signalman that it is working properly at night.

Special Signals.—For shunting and other purposes auxiliary to the operation of main-line trains a variety of

shapes and positions are employed for the signal arms governing such train movements, and some confusion in

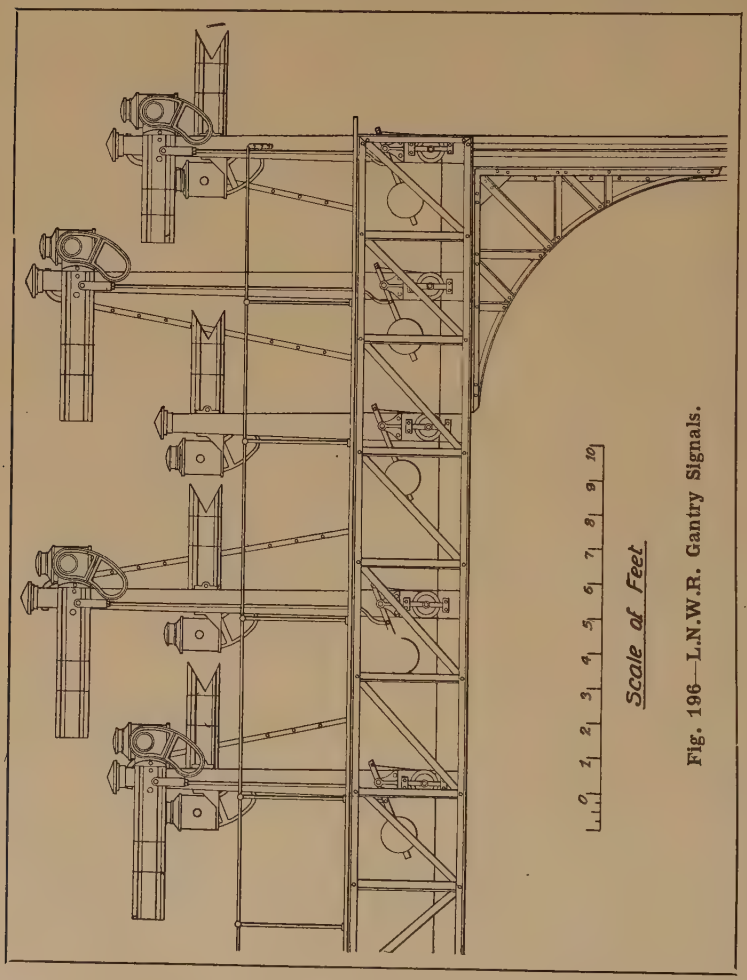


Fig. 196—L.N.W.R. Gantry Signals.

terms and application may be observed in reviewing current railway practice.

"Calling on" arms are fixed to posts below the main signals, and are used to "call on" a train for a short distance, limited by the general knowledge of the men, against the home signal, which may be at danger. Figs. 192 and 193 are examples (L.N.W.R. type), and consist of a small arm which normally blinds the blue, white, purple or green signal light used, but renders it visible when the signal is "off."

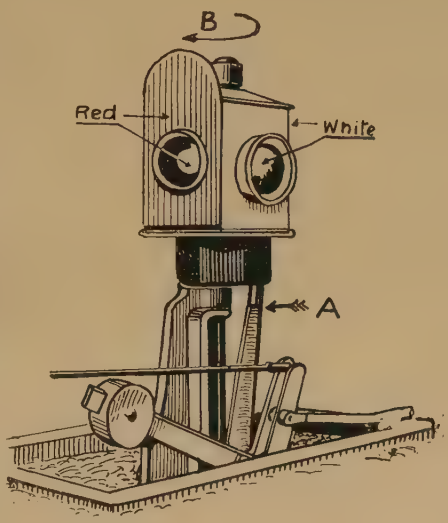


Fig. 197.—L.N.W.R. Ground Signal

On the G.E.R. a "calling on" signal arm in the shape of

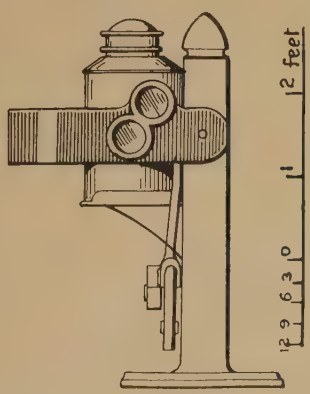


Fig 198

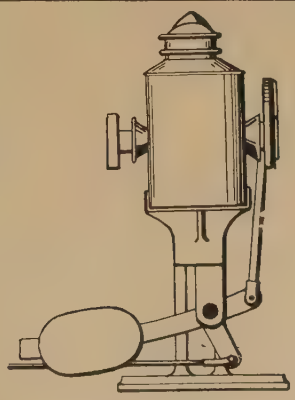


Fig. 199

Figs. 198 and 199.—Elevations of Semaphore Ground Signal

a cross is used with an "all right" light in the form of a green cross, as shown in Fig. 194.

G.W.R. Standard Signal Arms.—With reference to special signals the most complete system is, undoubtedly, that which is standardised throughout the Great Western Railway Company's line, and a set of diagrams showing their signals is, therefore, included here.

In Fig. 190 (*a*) = home signal, (*b*) = distant signal, (*c*) = shunting signal, (*d*) = backing-out signal, (*e*) = signal allowing exit from a siding; usually on its own post, but may be in a lower position on a main line post, (*f*) = tall signal with lamp lower down the post, (*g*) = duplicate arm on *f* near bottom of post, (*h*) = entry signal into a facing siding, usually on a main line post, (*k*) = limiting angles of semaphore arms.

Gantry Signals.—Where a set of signals must be arranged to span several roads it is usual to mount the posts on a bridge or gantry over the rails. A very fine group of model signals is illustrated in Fig. 195. The two arms which are in "off" positions are on the tallest post, and are, of course, those governing the main line. Fig. 196 shows a part of a gantry of L.N.W.R. signals, in which arms refer to trains running in two directions.

Ground Signals.— For controlling movements of trains and light engines through crossovers and for backing into sidings leading in a trailing direction from the main line, ground signals, or "Tommy dods," are used. These are of two main types: (1) The revolving signal, which may be actuated by the actual movement of the points, and (2) miniature semaphore signals, as illustrated in Figs. 198 and 199. The revolving signal takes several forms, that used on the L.N.W.R. being shown in Fig. 197. The red side faces the driver when the points are in normal position,

i.e. set for the main line, but when pulled over for the crossing or siding the signal revolves, as shown by the arrow B, and the white face is presented to the trainmen. The arrangement of lights varies on different lines. In the signal illustrated, the lever at A engages an eccentrically-placed hole in the lamp body and rotates the latter when it swings. In some cases the lamp body is painted all one colour, except for the indicating side, which has an inclined white stripe on it representing a semaphore in the "line clear" position. This side is only seen by the driver on the "right-away" signal being given.

Arrangement of Siding Signals.—The shunting of a train into a siding involves the use of a special arrangement of signals, and the presence of any such stopping-place introduces one or two additional signals, which should be noted (see Figs. 200 to 202). If the siding is on an ordinary straight main line without a station, then the signals required are as shown in Fig. 202, at A. No. 1 is the main line distant, No. 2 the "home" signal protecting the siding. Farther on, a train's length away from No. 2, is an "advance" signal, No. 3; No. 4 is the "starting" signal for trains already in the siding, which will require to come out on to the main line, and No. 5 is the backing "Tommy dod" or ground signal. Both the latter are interlocked with the points, and in real practice the main line is protected by a catch point (Fig. 200), or a safety siding (as shown in Fig. 201) near to the siding starting signal, so that a train therein, with a disobedient driver, cannot run out and foul the main line. These are not absolutely necessary in ordinary model work, but are illustrated in two positions in Fig. 200.

When a main line train is passing the siding (see A, Fig. 202) all the three signals (Nos. 1, 2, 3) would be "off,"

otherwise, for a train which is required to shunt back, the distant (1) and the advance (3) would remain at danger. The "distant" is, therefore, interlocked with the "advance"

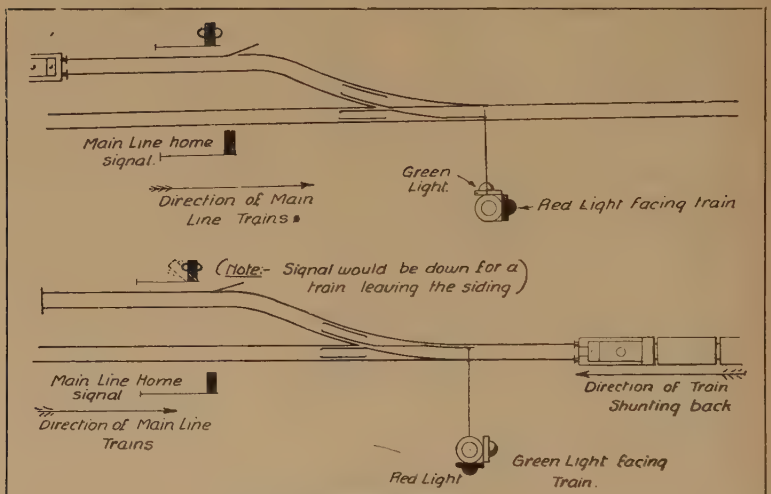


Fig. 200.—Siding Signals

as well as with the "home" to prevent it showing "off" if the advance is at danger. The diagrams C and D show the signals and train movements during the various periods in the operation of the siding section. In diagram C the train, having moved forward to the advance (3) signal, the points are moved over, the ground signal showing a green or

Fig. 201.—Safety Points at a Siding

"all right" light to the driver looking back at it. The train, therefore, proceeds into the siding, when, on the reinstatement of the point levers any number of main line trains

can pass, as shown by A. At such time as it is necessary for the train to leave the siding, the siding starting signal (4) and advance starter (3) are pulled off after the points have been set over. In the diagram D the ground signal (5) is shown at danger. This would occur only if the signal is operated by a separate lever to the points. If it is worked by the points, then it would show green. Its significance

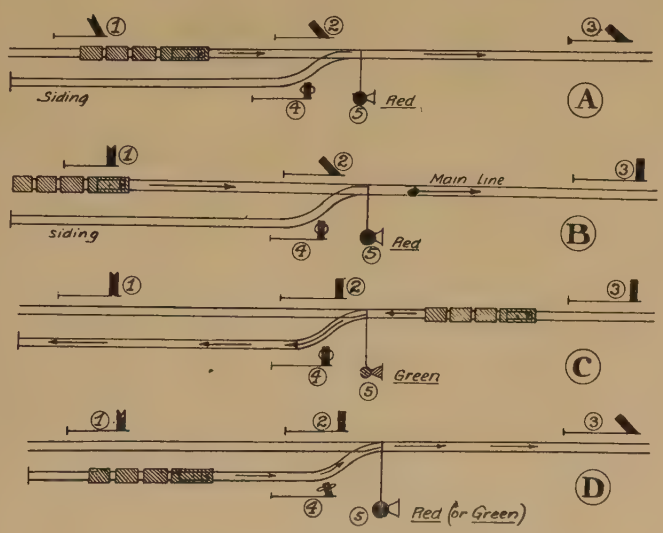


Fig. 202.—Train and Signal Operations in Shunting

under the circumstance, shown by D, has no bearing on the movement, unless it is used to show a green or a red light in both directions, when it could supersede the siding starting signal No. 4.

In model work it is usually important to reduce the number of signals to the minimum. Signals are luxuries, and no lives will be lost by an accident caused by lack of signals.

Station Signals.—As there are several complete volumes on railway signalling, the whole of the problems involved in arranging the signals of even a simple station or junction in a manner which would merit the approval of a Board of Trade inspector, cannot be discussed in a book such as this. So long as the signalling on a model line does not flagrantly transgress the proper practice and thereby offend the senses

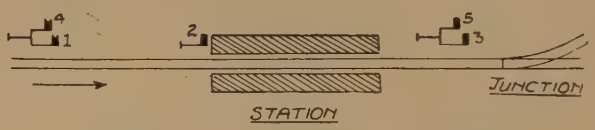


Fig. 205.—Station Signals at a Junction

Fig. 203.—Signals at a Simple Station

Fig. 204.—The Use of the "Advance" Signal

of an experienced railway man, the system may be said to be good. The signalling of a simple station is shown in Fig. 203 at the forward end of the platform. The latter's function is to give the "right-away" signal to a train which may be stopped at the station. Where a siding platform is planned at the outward end of the station an extra signal, called an "advance," is necessary (see Fig. 204). The trains going into this siding can then draw up into the section between the starter and advanced starting signal, and back

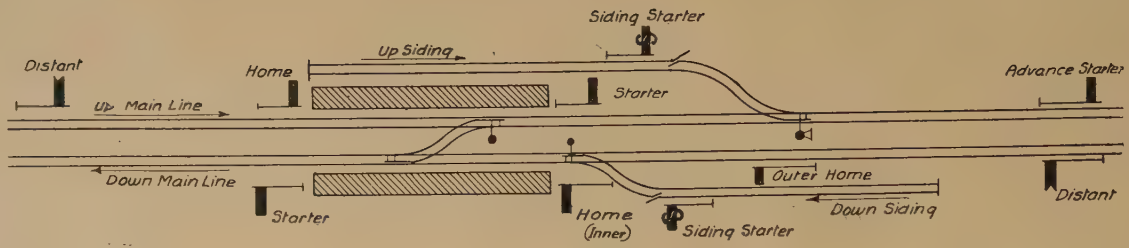


Fig. 207

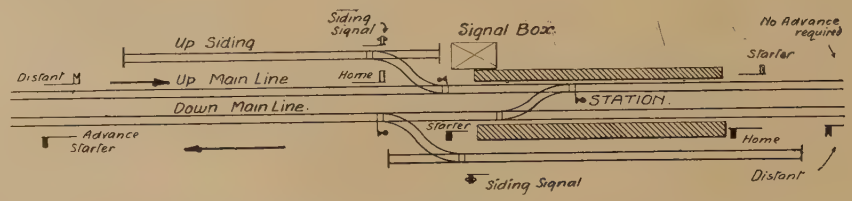


Fig. 206

Figs. 206 and 207.—Signalling at More Complex Stations

into the siding. The incoming distant signal at a station is never pulled off unless a through (non-stopping) train is expected, and both the starter and advance are "off."

Fig. 205 shows an arrangement of signals where a station is followed by a junction. The home signal No. 2 is a simple stop-signal only, but the distants are bracketed arms. These would be interlocked and repeat the position of the junction signals Nos. 3 and 5.

Figs. 206 and 207 represent two arrangements of a station on a double-line railway with sidings and advance signals.

Junction Signals.—For a simple junction it is necessary to employ four signals, that is if distant signals are employed, and these may be on separate posts, as shown in Fig. 208, or bracketed after the style of the signals already illustrated in this chapter. Five levers would be necessary in the cabin controlling such a set of signals, and it will be noted that out of many combinations of positions obtainable with six levers, only six are safe, and interlocking gear is necessary to prevent mistakes. Means for accomplishing this on a model railway will be described in another chapter. The diagrams show the two correct combinations for a passing train either to the main or to the branch.

Fig. 209 shows the elements of double-junction signalling for a two-road line. Even if the distant signals were eliminated there are sixty-four combinations for the cabin levers involved in such a plan, and of the combinations thus possible only thirteen are safe. The rest would lead an engine-driver into danger. It is important also that the points should be interlocked with each other, so that a train running past on the down main line should not be cut by a branch line train or engine operating on the up road.

The scheme illustrated in Fig. 210 is representative of a similar two-road junction station with a siding. All the

signals are numbered and described in the table on page 157. The advance signals Nos. 4, 8 and 11 may be dispensed with in a model without affecting the efficiency of the scheme, and the use of distant signals is optional, for reasons already noted. Many of the models used by instructional schools embody such an arrangement. An example is illustrated in Fig. 211. Here the signalling is slightly different from the plan shown in Fig. 210, owing to

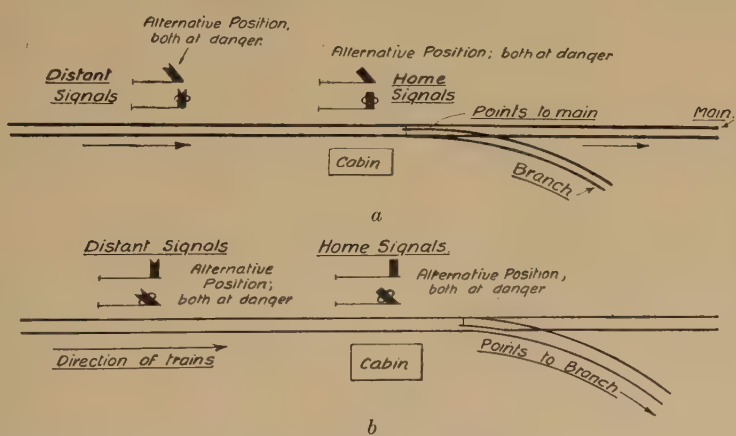


Fig. 208.—Junction Signals

the disposition of the refuge siding. These models are always very much reduced in scale length, for obvious reasons, and are generally made just long enough to accommodate a two-coach train.

Three-position Signals.—These are appearing once again on our railways, but the significance of the three positions differs from the early signals illustrated in Figs. 178 to 180. The modern 3-position semaphore eliminates the distant signal, the middle position (the old cautionary

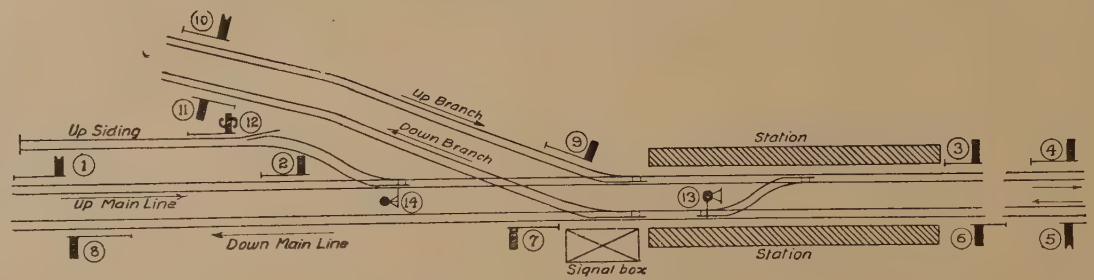


Fig. 210.—Double Junction Signals

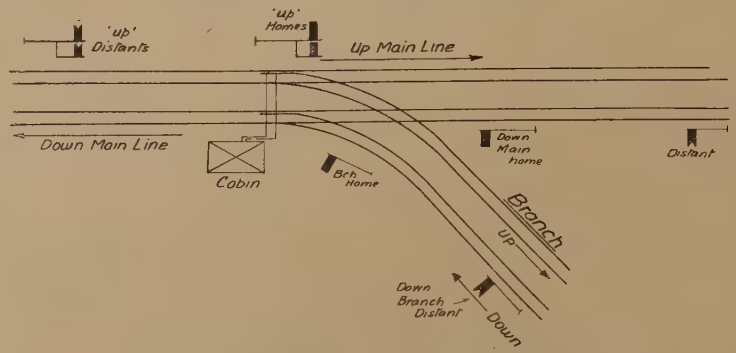


Fig. 209.—Double Junction Station and Signals

signal) indicating that the line is clear up to the next following signal. The "all right" position (i.e. with the arm vertical) shows that the next signal may also be passed, it being either in the second or third positions and not at danger. As a rule the semaphore is arranged with an upward movement from the horizontal "stop" position.

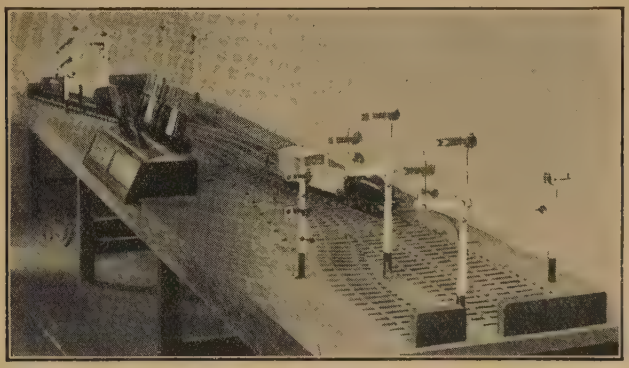


Fig. 211.—A Model of a Typical Station Signalling made for Instruction Purposes

List of Signals Required for Station Plan, Fig. 210

1. Up Main Distant.
2. Up Main Home.
3. Up Starter.
4. Up Advance (optional).
5. Down Main Distant.
6. Down Main Home.
7. Down Starter.
8. Down Advance (optional).
9. Up Branch Home.
10. Up Branch Distant.
11. Down Branch Advance.
12. Up Siding Starter.
13. Main Crossover Disc.
14. Siding Disc.

CHAPTER IX

Making Model Signals

MODEL signal-making, if one attempted to describe every detail or combination of components, would occupy a much larger space than that which is at the author's disposal, and, as the demand for metal parts and fittings is so well catered

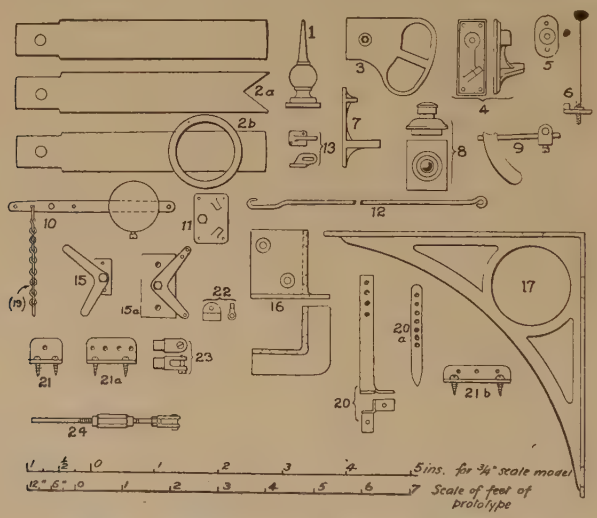


Fig. 212.—Bassett-Lowke's Standard Signal Parts

for by several trade firms, the descriptions of various designs of such fittings has not been overstressed. Information on the arrangement and use of signals is of paramount importance to the model-railway engineer. A few notes on construction are, however, included.

Scale Model Signals.—For the most part the various

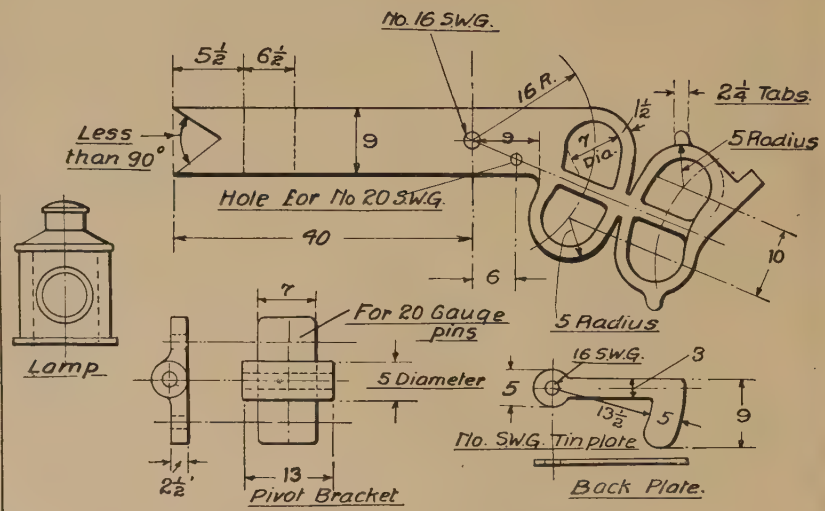


Fig. 213.—Details for Modelling Signal

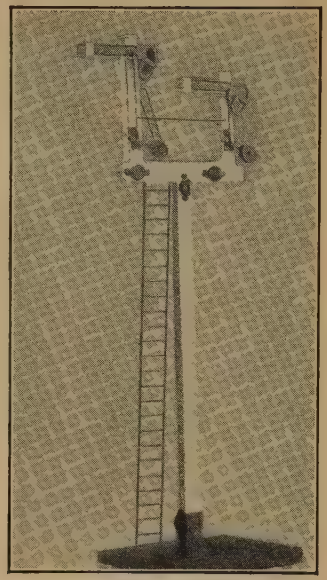


Fig. 214.—Bracket Signal without Bell Cranks

components of such signals are made up of die castings in one of the white-metal alloys. In the larger sizes (e.g. ¾-in. scale models) wooden semaphores are used, but arms of sheet-tin with the spectacles cast on are used in smaller gauges. The "Lowko" parts, illustrated in Fig. 212, are representative of the best and most complete sets. These are made in ¾-in. scale, and very faithfully reproduce all the main features of a British standard railway signal, expect, of course, such items as the base for the post (No. 16), which is designed for model purposes only. Similar parts are made for 3-in. scale signals, cast-iron and steel taking the place of white metal or sheet brass.

Scale Model Signal and Point Rod Parts

(*See* Fig. 212.)

1. Finial top of post.
2. Home semaphore arm.
2a. Distant semaphore arm.
2b. Ringed semaphore arm.
3. Spectacle (red and green).
4. Arm bracket bearing front.
5. Arm bracket bearing back.
6. Arm spindle.
7. Lamp bracket.
8. Lamp and top.
9. Back-light shade.
10. Lever weight and chain.
11. Lever bracket bearing.
12. Connecting rod, arm to lever.
13. Guides for rod.
15 and 15a. Side crank and brackets.
16. Base for post.
17. Bracket for gantries, etc.
19. Signal chain as No. 10.
20. Wire guides.
21. Point rod guides.
22. Lug for point rods.
23. Forks for point rods.
24. Point rod with fork and adjusting screw.

The illustration is arranged with a scale showing the actual sizes for ¾-in. scale model, and also a scale of feet which will be found useful in preparing drawings of larger

or smaller models. For No. 1 gauge this scale of feet would read off as centimetres, and for 1-in. scale ($4\frac{3}{4}$-in. gauge) as inches. The spectacle castings are rebated, and the red and green glasses are puttied or cemented in. Signal parts in gauge No. 0 and 1 are made by the "L.M.C." firm, quite a large range of white metal fittings of extreme neatness and delicacy being supplied.

Posts are usually made up of wood, and the lower ends may be pared down and glued into holes in the baseboard of indoor models, or fitted with cast-metal flanged sockets, which may be screwed to the base of the track. Finials may be of the helmet spike type, as used on the G.W.R., M.R., and other railways, or simply square weathered cappings, as used by the L. and N.W. and L.B.S.C.R. companies. Posts are always tapered towards the top.

Simple Model Signals.—The drawings (Figs. 181 and 182), included in last chapter, are representative of simple No. 1 gauge semaphore signals. Suitable details are illustrated in Fig. 213. The arm is pressed or otherwise cut out of sheet metal, and the spectacle glasses, which would be coloured celluloid or gelatine, would be inserted in between the parts of the spectacle before they are folded over. The back shade, pivot bracket and lamp are intended to be type-metal die castings, but where the amateur is only making a few signals these parts may be built up out of raw material. The same remarks apply to the lever and lever-pivot bracket, and the capping or finial of the post.

Model Wire-operated Signals.—Fig. 214 shows a model 1-in. scale bracket signal, in which the wires are led up to the posts round suitable pulleys, no bell cranks being employed. The advantages of the system are not marked in the case of small models.

Signal Ladders. — These are, on small-gauge lines,

usually omitted, because of the difficulty of making them sufficiently fine in detail. Where used, metal strip is punched with holes for the wire ladder rungs, the latter being soldered in to make the job secure. Any outside roughness may be filed off afterwards. To do this work as well as possible and to accomplish the task of soldering

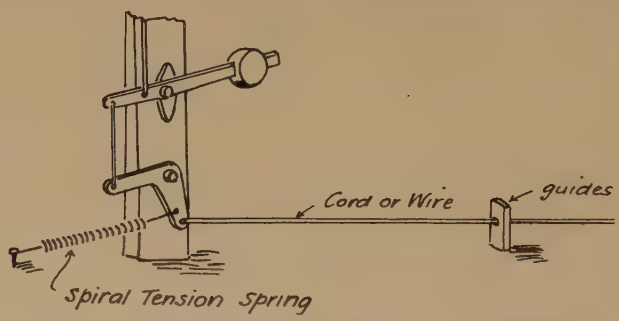


Fig. 215.—Spring Device to Assist Return of Signals

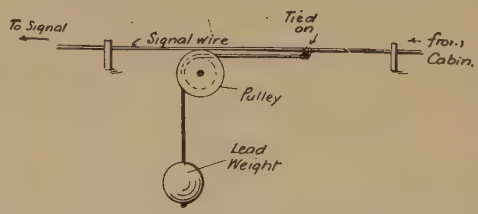


Fig. 216.—Counter-balance Weight in a Long Signal Wire

with ease the ladders may be held in a wooden jig consisting of a strip of wood slightly narrower than the latter, with saw-cuts formed in it to hold the rungs.

Signal Wiring.—For wiring signals, sewing thread, copper wire, chain, or even fishing cord are used, with varying degrees of success. Such wires are guided round pulleys, through screw eyes or sheet-metal guides (see Fig. 212, item Nos. 20, 20a), with either gravity or spring

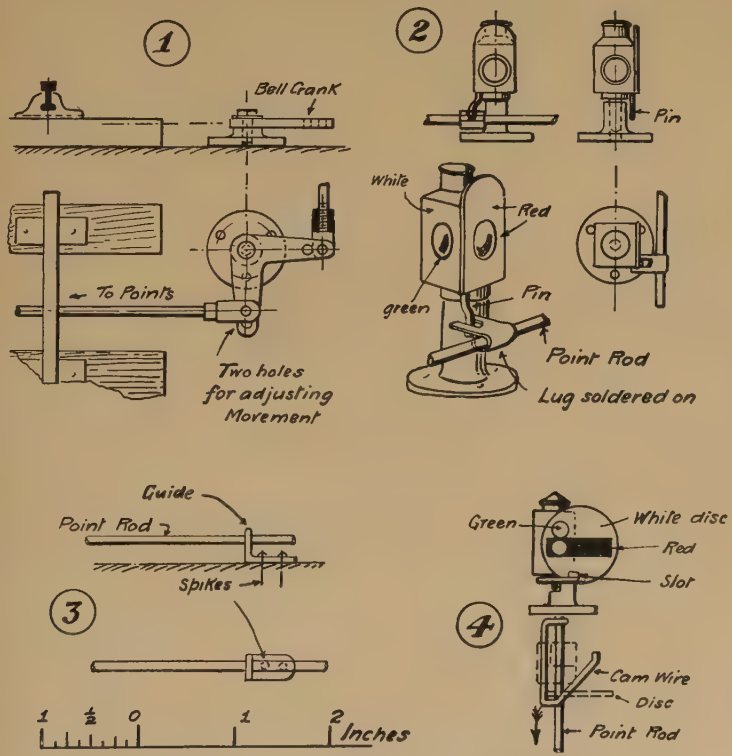


Fig. 217.—Point Rod and Ground Signal Details

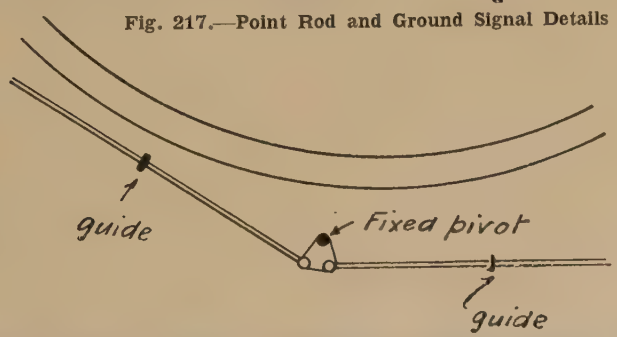


Fig. 218.—Pivoted Point-rod Connections for Curved Sections of Line

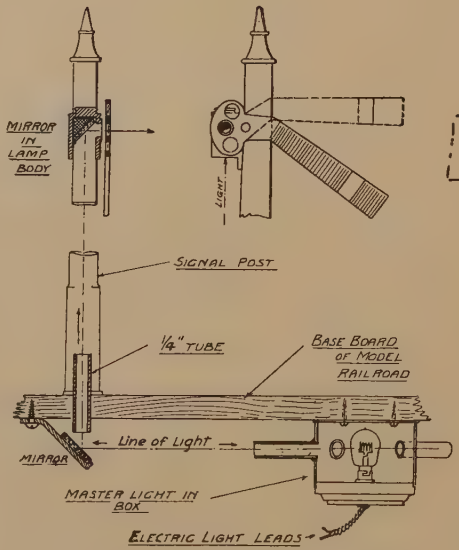


Fig. 220.—Indirect Lighting of Signals (American-type Signal)

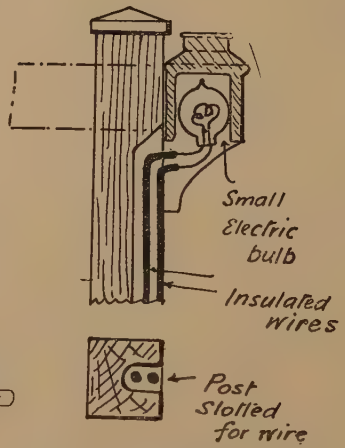


Fig. 219.—Method of Lighting Signals

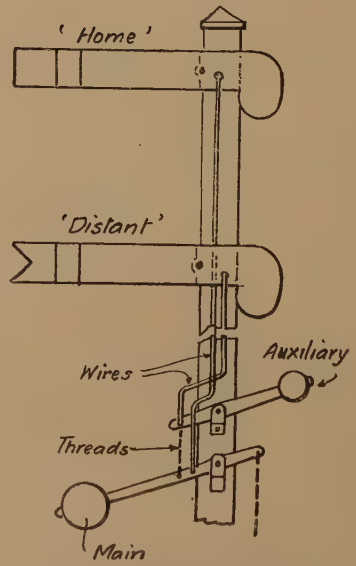


Fig. 221.—Slotting Signals

returns, just as the ingenuity of the model maker suggests. One of the most successful wires used by Mr. H. L. Stevens for operating points at a distance against a weight or a spring fitted at the points to return the same to normal position, is a three-strand high-tensile steel wire, which is really a part of the wire rope used for the lighter controls of an aeroplane.

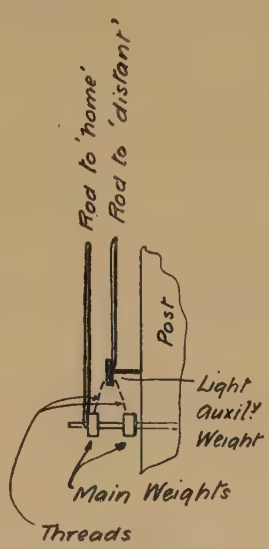


Fig. 221A.—Detail of Slotting Signal

Where a fine copper wire is used the resistance to movement should be slight. Copper wire has little elasticity, and if stretched beyond its limit will show a permanent increase in length. Sewing and other threads are affected by climatic conditions, and, therefore, lengths constantly require adjusting. To assist the return of a long "wire," weights or springs may be arranged, as shown in Figs. 215 and 216. By using relays of this kind no extra strain is put upon the parts of the signals. The latter can be made extremely delicate in comparison with the wire, the actuating lever, and to the additional forces applied to assist the return to "danger" position.

Point Rod Connections.—Point rods are usually made of $\frac{1}{16}$-in. brass wires in smaller models, and are guided through angle-plate guides, as shown in sketch No. 3 (Fig. 217), and items Nos. 21, 21a and 21b in Fig. 212. To a small extent such rods may be bent round curves. Pivoted connections are, however, to be preferred (see Fig. 218). These are small triangular plates of metal

pivoted to the substructure of the railway at the apex. They should not be placed too near to a guide.

Bell Cranks for Pivot Rods.—Bell cranks, as well as all other fittings of a working model, must be made of more robust dimensions than the scale equivalent of a full-size example would suggest. Where the substructure is sound, Sketch No. 1 (Fig. 217) shows a suitable arrangement. The bell-crank is pivoted to a support screwed to the base of the line. The bell-crank arms have two holes in each to fit the forked ends of the rods, so that by changing the relative positions of the pins in these forks three different lengths of travel can be obtained.

Actuating Disc Signals.—In real practice disc or other ground signals are operated by separate levers in the cabin. Model makers usually prefer to simplify things by connecting these signals to one of the rods of the points to which they apply. Sketch No. 2 (Fig. 217) is typical of this, while No. 4 shows a scheme for actuating a type of rotating disc signal which has a red bar painted on it. The rotation inclines this bar to give the "all right" signal. The movement of this disc can be obtained by meshing a notch on the edge of the rotating disc with a cam wire soldered on to the top of the point rod.

Lighting Model Signals.—The lamps of model signals are often illuminated at a comparatively extravagant expenditure of wiring and battery current by small pea lamps. The only lamps that at one time could be obtained were the carbon filament lamps made for electric tie pins and other novelties, but of recent years metallic filament lamps are obtainable. The screw connections of the latter are rather large, and may have to be removed when fitted to small-scale signals. The wiring may be concealed in hollow or grooved posts. Some reduction in the amount of electric

power used may be obtained by running the lamps in series in sets, or at a lower voltage than the nominal working pressure. Only a glimmer of light is necessary.

The indirect system may be applied to an indoor railway. The baseboard of the track should be curtained off to the floor, and underneath one or more electric lamps of ordinary candle power are fixed in such positions that by small mirrors the light can be conducted to mirrors fitted into the hollow of the signal lamps, as indicated in Fig. 220. Stations, clock towers, yard lamps and other accessories of the line may be lit up from the same source in the same manner.

Slotting Signals. — Where two signals—such as a home and a distant, which refer to one line of rails—are fixed on one post and are controlled by two men, they may be "slotted," i.e. interlocked, so that the distant cannot be made to show the "off" or "all right" signal while the home down remains at danger.

CHAPTER X

Model Railway Signal Interlocking

WHILE the writer intends to describe one of the full-size systems of arranging the interlocking of railway signal levers in a form which can be modelled by an amateur of average skill, it must be admitted that there are only a few who get so far advanced. Less delicate and less intricate work is therefore introduced, and, after the description of the less intricate requirements of railway practice is discussed, some simple devices applicable to working models will be dealt with.

Locking Home and Distant Levers.—The "distant" signal may be considered as a repeater of the indications of the "home" or "stop" signal, but as it is worked by an entirely separate lever it is important that its indications should not conflict. Before 1846 signals and point levers were operated by levers close to each individual signal post or crossing. When a concentration of the operating levers became essential a new trouble arose, viz., the danger of the signalman pulling the wrong lever—not a difficult matter where there happened to be twenty or thirty such levers confronting him. In the 'forties and 'fifties a Mr. Stevens and a Mr. Saxby introduced various schemes, which have been elaborated from time to time, to reach the present state of perfection.

In the case of the "home" and the "distant" it is necessary to prevent the "distant" signal lever being pulled "off," unless the "home" is already at "line clear," and to prevent a reverse action. If both are "off," then the

"home" signal must be locked in that position until such time as the "distant" signal is released.

In a model this is accomplished in a manner by the bracket scheme. On the particular lever, which is the second one to be pulled (the distant in the present case), a bracket made of stiff strip-metal is soldered. This bracket

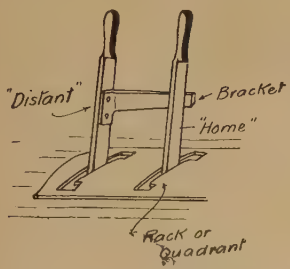


Fig. 222.—Bracket Locking

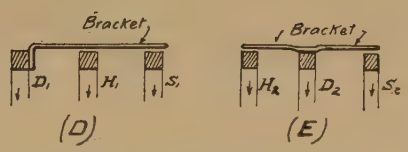


Fig. 224.—Interlocking "Home," "Starter" and "Advance" Levers

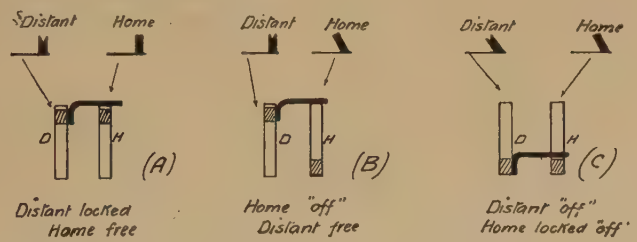


Fig. 223.—Interlocking a "Home" and "Distant" Lever

is sufficiently long to engage the first one, as sketched in Fig. 222, and its action is shown by Fig. 223. At A both signals are at danger, and the "home" only is free. Once this is pulled the "distant" lever is free, as shown at B. In the next diagram the "distant" lever is pulled "off," and when in this position the bracket automatically locks the home signal. Where three signals, such as the home, distant and starter, have to be interlocked the require-

ments are that the starter is always free, also the home signal, when all other levers are back. The distant must only be unlocked when the home and starter are showing "line clear." To accomplish this the bracket fixed on the "distant" lever would be lengthened to embrace both the home and starting signal levers, as illustrated in Fig. 224 at D. Should the long bracket be objected to, the distant lever could be placed in between the other two and have a bracket arm extending both to the right and left, as at E. This arrangement would, however, upset the accepted sequence of the levers in the cabin. It is usual to place levers in the same relation as the position of the signals outside the cabin they operate. In a working model this rule may be relaxed slightly, but the writer would prefer it maintained in the present instance. Therefore, he would suggest the method D (Fig. 224). In the sketch D_1 D_2 are the distants, and H and S the "home" and "starting" signals respectively.

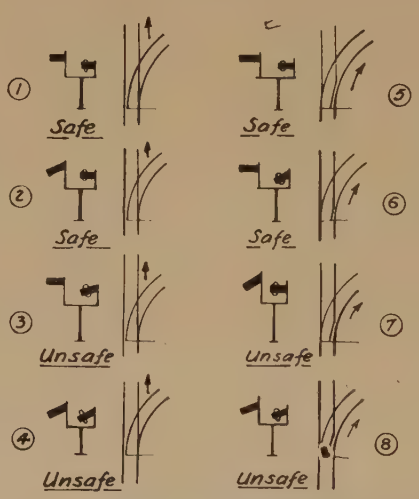


Fig. 225.—Safe and Unsafe Combinations of Junction Home Signals

Locking Point and Signal Levers.—The next important function of an interlocking gear is the connecting

up of signal and point levers so that any signal cannot be made to give a wrong conception of the state of the points to which an engine-driver may be approaching. Taking the simplest element (Fig. 208, Chapter VIII), an ordinary junction on a single line of railway which is used for trains running in one direction only.

Fig. 225 shows the safe combinations of a set of signals and three levers with the distant signals omitted. While the use of distant signals would involve the two levers to

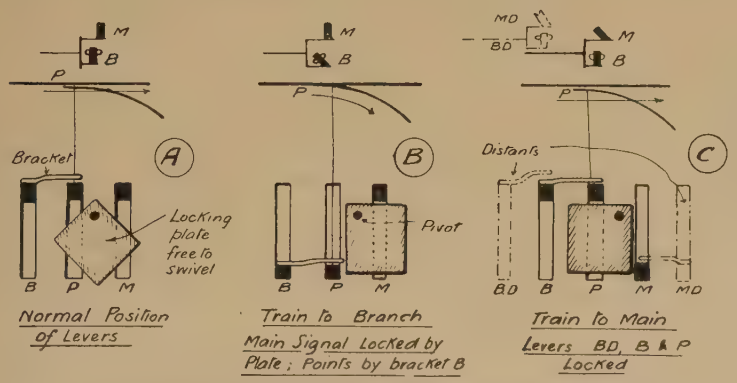


Fig. 226.—Mr. Guy Mitchell's Model Locking Gear

make the total of five shown to be necessary by the plan (Fig. 208, Chapter VIII), the bracket system of model interlocking renders any special consideration of the "distant" levers unnecessary. So long as they are placed next to the "home" levers and fitted with brackets they can take care of themselves. Of the total of eight combinations, shown in the simplified scheme (Fig. 225), only four are allowable, and the interlocking must prevent the others happening.

A simple, ingenious, and easily-made scheme, devised by the late Mr. Guy Mitchell, of Totley, for an elaborate and

successful garden railway he built, can be introduced into small installations where there is not much locking between sets of points. Its elements are shown in Fig. 226. On a horizontal table or shelf (Fig. 227) below the quadrant slots for the levers in the floor of the cabin, a wooden board or thick metal plate is fitted on a pivot suitably placed. This pivot is so arranged that the square plate fouls and thereby locks either one signal lever or the other.

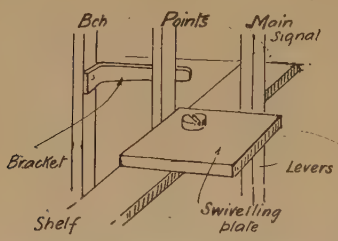


Fig. 227.—Further Details of Mr. Guy Mitchell's Locking Gear

Fig. 226 shows the junction in its three main positions. At A (Fig. 226) the points are set in the normal direction, i.e. all right for the straight line. The signals are all at danger—also the normal arrangement—but either the main

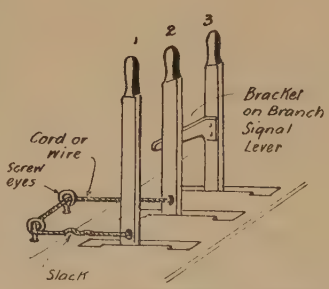


Fig. 228.—Greenly's Bracket and Cord Interlocking Signal

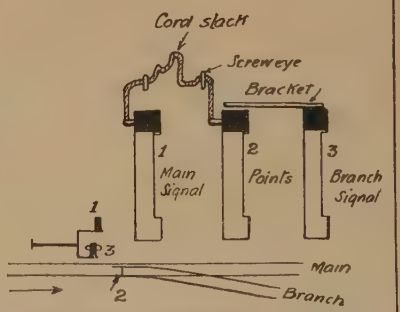


Fig. 229.—Interlocking a Simple Junction

line signals can be pulled off or the points can be shifted to lead a train on to the branch line. If the latter course is adopted by the signalman the locking plate will move to

the right, to position B (Fig. 226). The branch signal lever may then follow, and the signals and points take up the arrangement shown in sketch B, the plate securely locking the main line signal lever.

Should, however, the train controller elect to pull the main line signal lever from the position shown in diagram

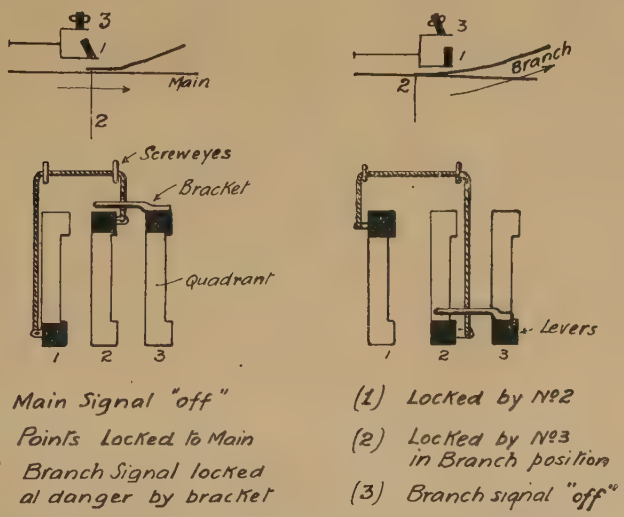


Fig. 230.—Further Details of Simple Junction Interlocking

A, the plate immediately locks up the points, and, by virtue of the bracket, the branch line signals, as illustrated at C. If the distant signals are used they will be governed by the locking of the home signals through their brackets, and a perfectly safe arrangement will be obtained. The distant signal levers are shown by the dotted lines in diagram C only. In construction nothing could be devised to involve less work, and for simple junctions the writer would heartily recommend this, or any similar scheme.

On Mr. Mitchell's railway there was only one signal-box, and it controlled four junctions, each having its set of three levers. The junctions were entirely separate from each other, and each had its own locking-plate. There was no need for any cross-locking of the respective junctions.

Greenly's Cord and Bracket Model Signal Locking.—The limitations of Mr. Mitchell's scheme will be noticed when it is attempted properly to interlock a complicated station yard with its innumerable points and signals. Previously to the making of the device just described the author had worked out a simple interlocking mechanism to deal with larger lay-outs. This arrangement can also be used in conjunction with the bracket system of locking. In its elements it consists of fitting certain levers with a cross-connected cord passing through screw eyes fitted to the floor (or sub-floor) of the cabin. Fig. 228 illustrates the device in perspective.

The cord used should be of a material which will not stretch. To this end the writer has used both catgut and flexible picture wire with success. The position of the levers for a single junction, such as described in the previous paragraph, is illustrated in Figs. 229 and 230. The same combinations could be obtained by using the mechanical contrivance illustrated in Fig. 231. Here signal and point levers are connected by slotted links to a pivoted cross bar in front of the levers, so that when signal lever No. 1 is pulled off the movement of the cross-lever will lock the centre one. This scheme is applicable to a simple junction, but does not lend itself to further development. It is no real improvement on Mr. Mitchell's scheme, and involves more work in the making.

The cord-locking, however, appears to have no limitations, and can be applied to junctions with both "up" and

"down" line signals. In all cording arrangements the adjustment in the length of the cord is an important point. To lock up a lever, such as is done to No. 2 by lever No. 1 in Fig. 230, the cord must be just tight when the signal and point levers are in the locked positions, and, therefore, some method of gripping the wire or cord where it joins the lever is suggested. Either of the schemes X and Y, shown in

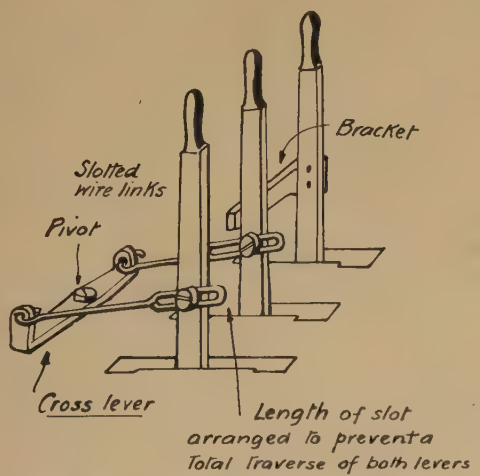


Fig. 231.—An Alternative Form of Locking Gear

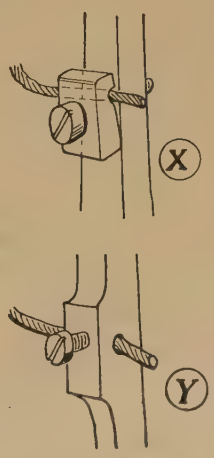


Fig. 232.—Fixing Locking Cords

Fig. 232, would, no doubt, work very well. That at X is, perhaps, the better of the two, as it does not weaken the lever. With scheme Y it would be almost necessary to reinforce the lever at the point of the attachment of the wire by enlarging its section locally. This is possible by using cast-brass levers, but such are not so satisfactory as the harder and stiffer drawn brass rod usually employed for model signal and point levers.

An example of how a nine-lever box can be interlocked is shown in Fig. 233. The signals govern a plain junction with trains running in both directions, and not only does the cord and bracket locking prevent the points and signals being incorrectly set in relation to each other, but prevents an "up" line signal being made to show "line clear" when the corresponding "down" signal, or any other "down" line signal which may not be locked by the points, is in that position. In the plan, lever No. 5 is the one which operates the points, and the attachment for the cord to this lever is

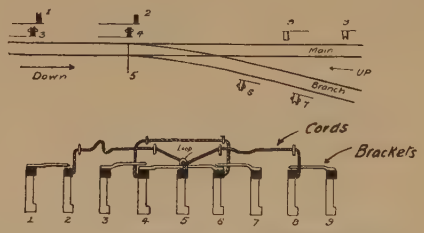


Fig. 233.— Locking a nine-lever Box by Cord and Bracket Method

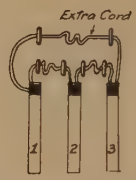


Fig. 234.—Method of Cross-locking with Duplicate Cords

a metal loop through which the cord from levers Nos. 2 and 8 is allowed to pass as freely as possible. The slack in the length of this cord or wire should be sufficient to allow only one lever of the three (No. 2, 5, or 8) to be pulled over. The position of the two central screw-eyes at No. 5 should, therefore, be adjustable. If they are too close together the point lever would want to take up a greater amount of slack than is available. The eyes are, therefore, fixed a short distance apart, as indicated. When pulled over, lever No. 5 should just tighten the locking cord. In a complicated interlocking scheme of this kind the cords or wires would lay on the face of the signal frame or sub-floor,

and no difficulty should be experienced in arranging them so that they will flow over each other quite easily.

Although the method of arranging a running loop for the wire connecting-levers (Nos. 2, 5 and 8, Fig. 233) with the eyelets set a slight distance apart may prove reasonably

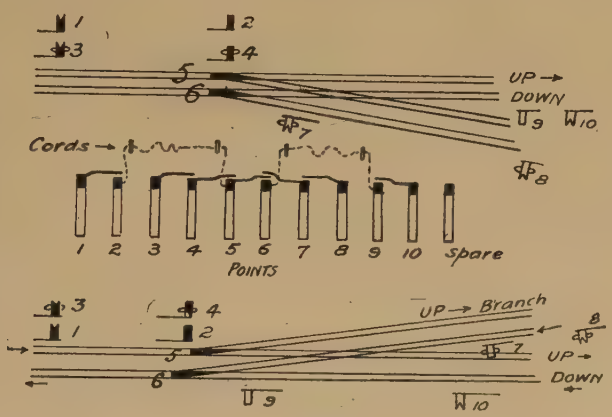


Fig. 235

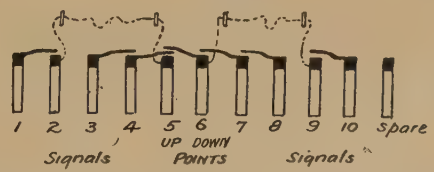


Fig. 236

Figs. 235 and 236.—Locking for Double Junctions

satisfactory, it may not always be possible to fit the eyelets in the exact position determined by the geometry of the problem. The system of locking cords indicated in Fig. 234 may then be adopted. Separate cords would be used for connecting levers No. 2 to No. 5, and No. 5 to No. 8. The pulling over to the branch line of the point lever (No. 2) would, therefore, lock the main line signals 2 and 8 by the

independent cords. With the point lever No. 2 in its normal position it would then be possible to select either the "down" line signal No. 2 or the "up" line signal No. 8. An extra cord between these two is, therefore, used as shown in Fig. 234. Only one of the signals can thus be placed at "line clear," this action locking the other as well as the points. This introduces another useful feature.

Cord and Bracket Locking for a Double Junction.—A double junction requires only two more levers than the single-road junction worked with trains running in either direction. The reason of this will be understood from Figs. 235 and 236. While two points are employed the number of signals required is no more than that necessary for controlling the single junction, owing to the up and down lines respectively being unidirectional. The cording is extremely simple, and the drawings are arranged for both a right- and left-hand junction. Although the disposition of the signal levers in the cabin is not strictly correct when viewed from the full-size railwayman's standpoint, the arrangement is reasonably accurate, and would cause no confusion in actual use.

Only two cords are necessary, the brackets on the back of the levers doing most of the work. The point levers are fitted up together in the centre of the cabin, the "up" lever No. 5 being at the end of the cabin facing trains travelling on that line. All the levers for the "up" and "down" signals are at the "up" and "down" ends of the signal frame in each case, so that the cabin has some pretentions to a true representation of an actual one in this respect.

With everything in the normal position (see Fig. 235) it will be noticed that Nos. 2, 6, and 9 are the only levers that are free. Lever No. 5 could not be pulled over until the

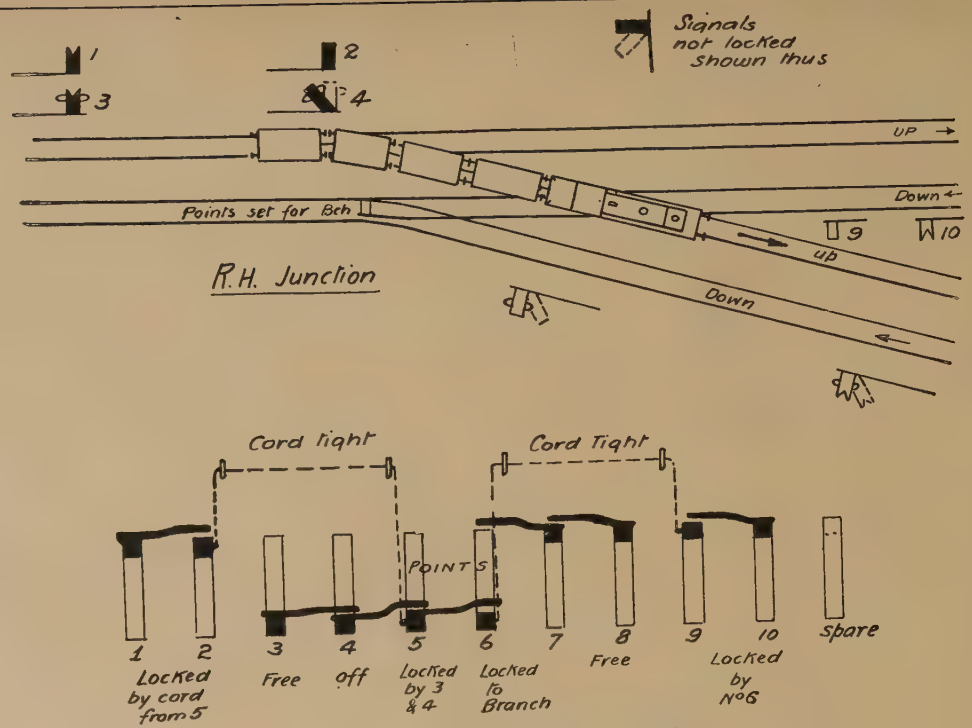


Fig. 237.—Locking System in Operation

"down" points are set for the branch. This is usual, although (see the case of a right-hand junction) it cannot prevent a "down" main-line train from running past a signal at danger and crashing through an "up" train turning off on to the branch line. In Fig. 236 (left-hand junction) the interlocking of levers Nos. 5 and 6 would prevent an "up" train proceeding over the diamond crossing, across the path of a "down" branch train, by virtue of the fact that the point lever No. 5 must be pulled over before lever No. 6.

Referring back to Fig. 235 (the right-hand junction), lever No. 6 locks Nos. 9 and 10, and frees the "down" branch signals Nos. 7 and 8. If there is an "up" main-line train running through at the same time, signals Nos. 1 and 2 are free, but directly No. 2 is pulled off the points are locked, and, this being the case, the branch signals Nos. 3 and 4 are locked against movement. No. 2, of course, locks the "up" points, No. 5, the lever of which, in turn, locks Nos. 3 and 4. It will be seen, therefore, that lever No. 6 has the control of the whole scheme, it is literally the centre of the situation, and its movement influences every other lever in the cabin signal frame.

Fig. 237 illustrates the condition of the signal frame and locking when an "up" branch train is running through the junction and crossing the diamond. Lever No. 6 ("down" points) is pulled over for the branch, which, as already explained, is a necessary position. The junction home signal (No. 4) is "off," and its distant (No. 3) is free, and can be pulled off if necessary, or if it had already shown "line clear," could be replaced to the normal position. Levers Nos. 1 and 2 are locked by the cord from No. 5 and the point lever, No. 6, being set for the branch line, is locking the "down" main-line signals Nos. 9 and 10, while if a "down" train must be accepted, the levers for the branch

signals Nos. 7 and 8 are quite free. Of course, the signal interlocking in this case depends entirely on two cords, and extra "safety cords" could be applied to levers 7 and 9, and 2 and 4, which would doubly ensure, should the other cord break, the maintenance of a correct relationship between the points and the main- and branch-line signals.

Terminal Station Interlocking.—The locking for the

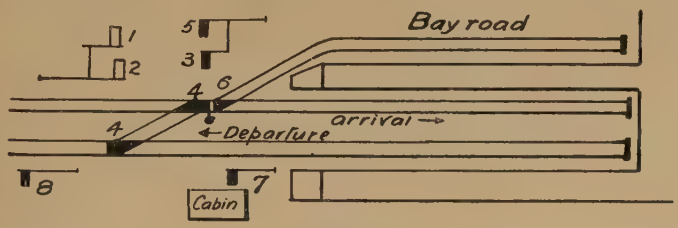


Fig. 238

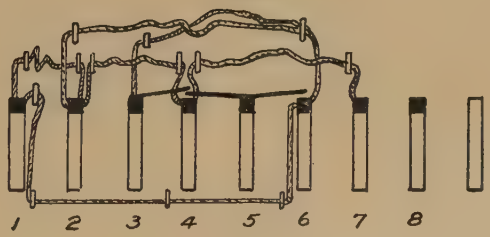


Fig. 239

Figs. 238 and 239.—Plan and Locking for Small Terminus

previous case—a double junction—is relatively simple compared with that required for a terminal or other station with sidings and crossover roads, that is, if it is desired to provide for all contingencies. The reason of this is that at a station trains and engines have to traverse so many lines and points in both directions. There are, therefore, two methods of dealing with the problems involved: one being to omit all cross interlocking of "up" and "down" signals,

and to lock only signals and point levers in such a way that they themselves do not conflict. The other scheme is, fully to interlock the "up" and "down" signals so that a train cannot enter a platform where another is signalled to leave.

For all practical purposes the model-railway engineer will usually be satisfied with the first-mentioned method, as the mere fact that both an "up" and "down" (arrival and departure) signal cannot by virtue of the interlocking be "off" at the same time, would not prevent a collision. Even if the levers are fully cross-locked a train might be occupying one of the platform roads, the signal given for an entering train, and a collision ensue. Therefore, what the writer has termed "cross-locking," although it would appear to be a step towards perfection and might tend to prevent accidents, does not provide for absolute safety. Short of employing the complicated mechanical and electrical devices used in real practice, reliance must be made on the vigilance of the model-railway signalman and engine-driver.

Fig. 238 shows a simple terminus plan with three roads and a crossover. The "up" trains would only run into the arrival road or the bay, but by virtue of the crossover trains could leave either platform on the outward (down) journey. The signals are, therefore, arranged to provide for this method of working the traffic. The plan of the interlocking is shown in Fig. 239. As it happens, a simpler-looking scheme is impossible. The "up" and "down" signals cannot be otherwise than cross-locked. Levers Nos. 1 and 2 are station home signals for arrival trains. They may, of course, be provided with distant signals, having levers adjacent to the home-signal levers and being interlocked by the usual brackets. As it would be unusual to place levers Nos. 1 and 2 at the other end of the box (at the R.H. end)

a method of locking Nos. 1 and 6 different to that described in previous examples is adopted. As illustrated, the cord passing along the front of the levers locks No. 1 to normal, when No. 6 lever is in the normal position. When it (the

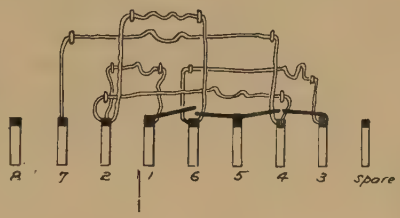


Fig. 240.—Alternative Plan of Locking for Terminal Station

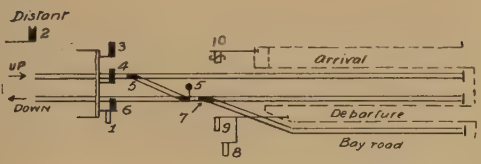
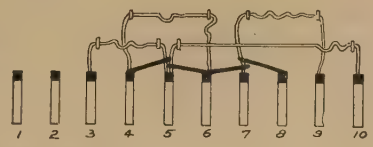


Fig. 241.—Plan for a Terminus with Facing Crossover

Fig. 242.—Simplified Locking for Fig. 241



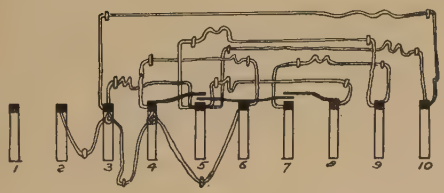


Fig. 243.—Full Locking for Fig. 241

latter) is pulled off, No. 1 is released. The reason for this will be seen from the rail plan. The points to the "bay" must be pulled over before No. 1 signal is placed at "line clear." It will be noticed that several levers have more than one locking cord, and, therefore, the attachment of the

wire or cord will require special attention. Where wires are used they may be soldered into holes drilled as close as possible in the lever, the adjustment of length being made at the other end, on a lever which, perhaps, has only one locking cord attached to it.

The signal lever No. 3, which starts a train out of the arrival platform on to the "down" road, is locked by a bracket over No. 4 (the crossover points) and its fellow-starting signal No. 5, being also dependent on the crossover

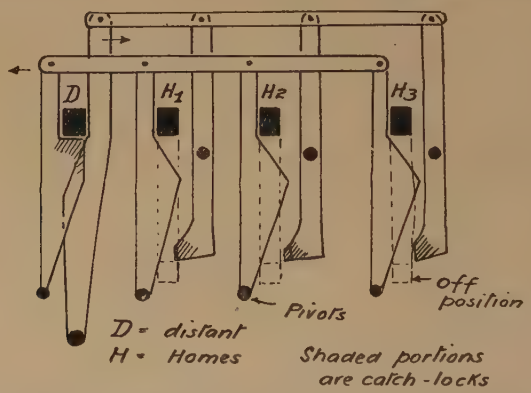


Fig. 244.—Method of Locking One Distant with Two or more Home Signals

and the points; No. 5 has a double bracket embracing both levers Nos. 4 and 6. The advance starting signal No. 8 is quite free. It simply allows a "down" train access to the main line, and does not involve any question as to where it started from. This signal should be sufficiently far away to permit shunting of trains to be accomplished within it.

Fig. 240 shows an alternative scheme of interlocking for the same plan. By moving lever No. 1 next to No. 6 a bracket can be used instead of a cord. This is a more mechanical arrangement. The terminal lay-out (Fig. 241) is similar to that illustrated in Fig. 238, the chief difference

being in the position of the "bay" road and the use of a facing crossover. This station does not allow outward trains to start from the arrival platform. A backing-out

Fig. 245

Fig 246

Figs. 245 and 246. Model Locking Signal-box Frame made by P. Boulger

signal, No. 10, is provided to control trains shunting out over the crossover. The "up" distant signal is shown without interlocking. If it is thought worth while to install this signal it may be provided with a mechanical locking

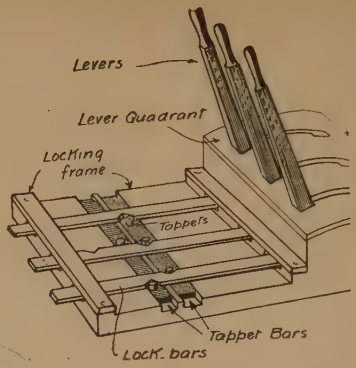


Fig. 247.—Tappet Locking Frame for Signal

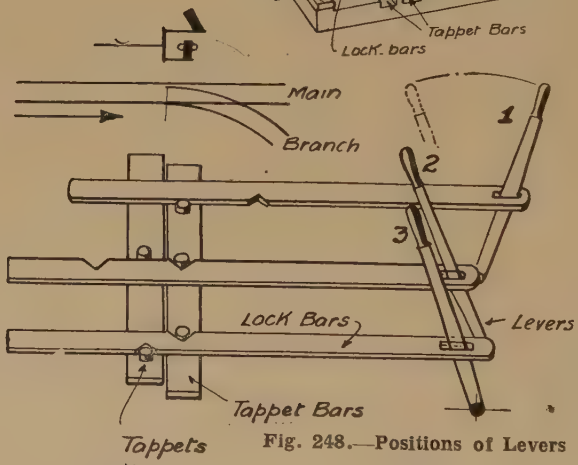


Fig. 248.—Positions of Levers

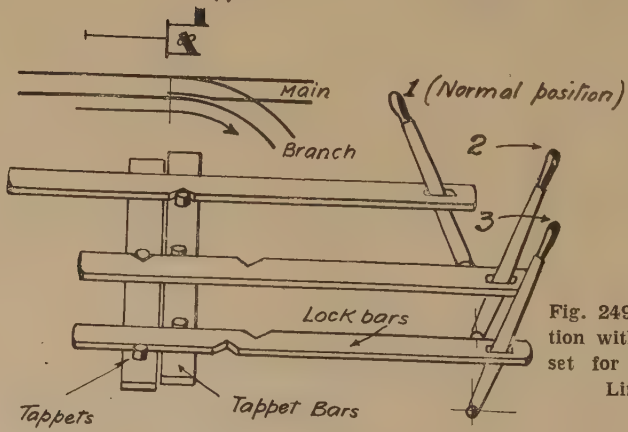


Fig. 249.—Position with Points set for Branch Line

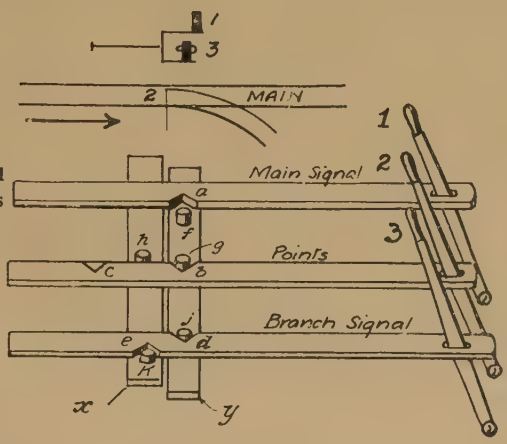


Fig. 250.—Normal Position of Levers

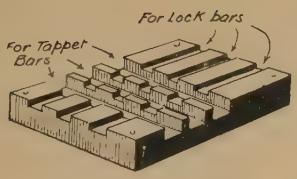


Fig. 252.—Sketch of Slide Frame for Tappets

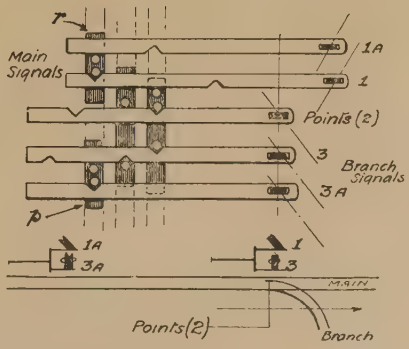


Fig. 251.—Tappet Locking for a Junction with Distant Signals

system, as shown in Fig. 243. Personally, the writer would suggest that it be made an outer "home" signal, and, like the "down" advance signal, be quite free. Fig. 244 represents a more complete scheme of locking, and here again it will be seen that lever No. 5 controlling the crossover is, to a large degree, the master of the situation. If a simpler scheme is desired, and signals 8 and 9 are used for both shunting and starting operations, the cords from Nos. 5 to 8 and 9 may be omitted, the shunting operations over the crossing No. 5 being controlled by a "Tommy dod."

Tappet Locking.—One of the faults of the cord locking, which readers may have already observed, is the fact that unless a signal or point lever is moved to its fullest extent the locking is inoperative. Further, two signals which are locked by a cord or by the slotted links (see Figs. 228, 229 and 231) may each be pulled half over. Of course, such a disadvantage is mitigated by the presence of the comparatively large amount of slack (back-lash) common to small models, and further, the partial failure of the interlocking scheme of a toy railway is not a matter of life and death. In full-size practice the locking gear comes into operation during the first part of the movement of a lever. One form, the oldest perhaps, of mechanical interlocking, is the tappet system. It is illustrated in an elemental form in Figs. 247 to 250. At the back of the levers a horizontal frame is arranged. This frame is so made that it will receive locking bars, which are attached to the levers. These bars run at right-angles, and immediately under them are tappet bars, which are free to slide endways in suitable grooves. On these bars pins or "tappets" are fitted. These engage notches in the locking bars, and the whole scheme is so devised that the tappets either release or hold the locking bars, according to the position of the signal and point levers.

Tappet locking is capable of the utmost degree of development, and may be made to embrace, in one scheme, literally hundreds of separate levers. The space available will only allow of the simpler plan being dealt with. In adapting

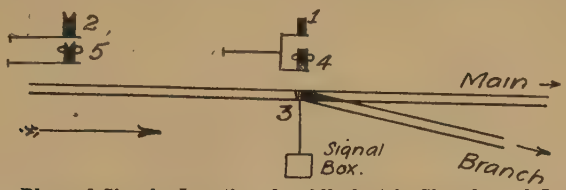


Fig. 253.—Plan of Simple Junction for All-electric Signals and Interlocking

it to his especial needs, the reader will require to use his ingenuity and to make suitable paper models to find out what is the least complicated arrangement he can apply to the particular case involved. For a simple junction, with three levers, only two tappet bars are required. These are

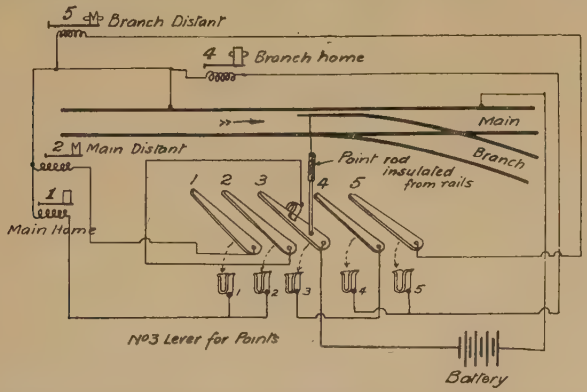


Fig. 254.—Electrically-operated Signals Locked by the Wiring of the Contacts

shown in the two positions necessary for trains passing to the main and branch lines, while the third view (Fig. 250) shows all the levers put back to the normal. In this case it will be seen that the points are quite free, and that the

signal levers are dependent on the position of the points. The notches in the locking bars serve both as locking notches and to provide the movement of the tappet bars. For example, the movement of the point lock-bar (No. 2) forces *f* into notch *a*, locking the main-line signal. The stud *h* is, however, then adjacent to notch *c*, and when the branch-line signal is pulled off (lever No. 3) stud *k* leaves notch *e*, these two studs being fixed to the sliding tappet bar *x*, and draws *h* into the notch *c*.

In Fig. 251 the writer has introduced distant signals, Nos. 1a and 3a, this requiring two new levers and an extra groove for the tappet bars, with two entirely separate tappet bars fitted into this groove.

As No. 3 branch signal is not pulled over (it is actually locked by the points and main-line signal) the tappet bar *p* is arranged to lock the distant-signal lever, No. 3a.

Referring again to Fig. 250, the tappet stud *f* is clear of the notch *a*. If, however, this stud did happen to be in the notch, the movement of No. 1 lever (main-line signal) would move the tappet bar into the position shown in the illustration. The main-line signal is quite free to move, but, as shown in Fig. 248, once it is shifted the stud *f* will rest against the plain edge of the locking bar and securely lock both the point and the branch-line signal levers by maintaining the studs *g* and *j* in their respective notches *b* and *d*, all these studs being attached to the one tappet bar *y*. If the point lever is moved instead of the lever No. 1, the frame takes up the position shown in Fig. 249. The stud *g* then rests against the plain portion of the bar. On the other hand, if No. 1 signal lever is pulled off, the notch in this lever's lock-bar will move to a position opposite the stud in the tappet bar *r*, and on the distant-signal lever No. 1a being placed at "line clear," the stud will move into

Fig. 255.—Interlocking and Signal Instruction Model as used by Large Railways

the notch, thereby locking the home-signal lever No. 1, as shown in Fig. 251.

It is essential that the tappets in a model locking frame should be strong, as the power applied to the lever is not a scale equivalent of that the real signalman uses. All parts of the frame must, therefore, be proportionally more robust than those of an exact-scale model. Some model makers use the heads of steel screws. This is good so long as the screws are at least $\frac{1}{8}$ in. in diameter. A better arrangement is to use studs of $\frac{1}{8}$ in. diameter silver-steel, driven into holes in the tappet bars. These bars should fit into guides, the usual method of making the frame being to mill out grooves in a thick plate of brass in two directions—at right-angles to each other—as shown in Fig. 252.

In designing a tappet system of interlocking for a particular plan of railway, a very simple preliminary model might be made with little blocks of wood moving in grooves to represent the signal and point levers, bracket and cord locking being used as a temporary measure—working out the final notches and tappets required for any given signalling scheme.

Electric Signal Locking.—As shown by the diagrams Figs. 253 and 254, signals which are electrically operated may be interlocked by a suitable arrangement of the contacts and wiring from the energising battery.

CHAPTER XI

Power Signalling for Models

General Notes. — In real practice, during the last ten to twenty years, there has been considerable development in the use of power for operating railway signals and points. The various schemes are too numerous and complicated to describe in detail, but include the use of both compressed air and electric transmission. Some systems employ a combination of both sources of power. For model railways both the air and the all-electric systems have been applied in a simplified form, but the electric-pneumatic scheme would appear to introduce unnecessary complications, and need not be considered.

Automatic signalling is a relatively easy proposition on a model line, but as ordinarily devised is quite a spectacular affair. It does not act as a means to safe working: the trains simply work the signals. The "Series" electrical system for model electric railways is, also, an interesting scheme working on the same principle. This is described in the author's book, "Model Electric Locomotives and Railways."

Pneumatic Signals.—To eliminate the innumerable wires, bell cranks and compensation devices, all of which introduce so many frail and troublesome fitments to a model line, the writer has tried with success a pneumatic scheme for operating signals. It may be applied to points, but this involves the use of a type of switch which is almost frictionless in its movements, and, further, its reliability would be easily impaired by grit being blown or knocked

up into the mechanism from the ballasting of the line. For signals a better scheme would be difficult to imagine, more especially as it does not need any extraneous power supply. As most model makers who have attempted a small-scale signal-lever frame know, the power available at the operator's finger is out of all proportion to the strength of the apparatus, and both signal levers, wires, and cranked

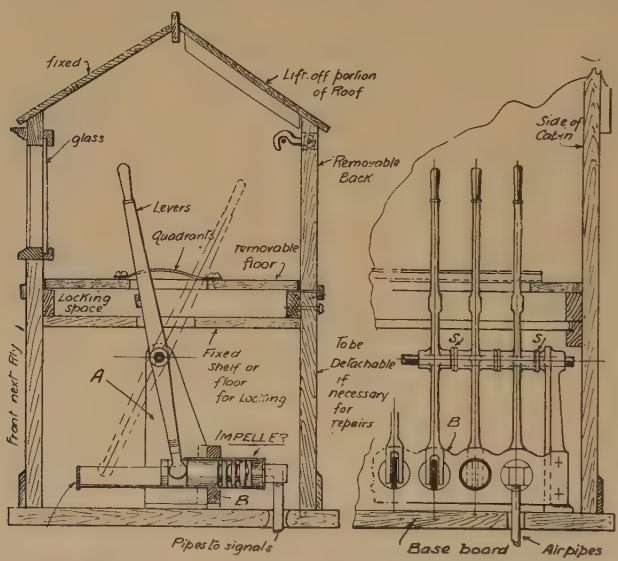


Fig. 256.—Signal Box for Model Pneumatically-operated Signals

connections have to be made heavier than would otherwise be desirable. The friction in the wires actuating a model signal only 10 or 12 ft. away from the box is, also, disproportionate to that involved in full-size mechanisms, and, therefore, it is difficult to attain anything like scale distances in the relative location of model signals.

With the pneumatic scheme most of these difficulties disappear. The chief element in the success of such signals

is obtaining some perfectly round, straight and light brass tubing and plugs turned to a nice sliding fit in them. Two sizes of tubes and plugs are required for a model signalling system.

There are also two methods of operating the signals which are equally good. In Fig. 256 the "impeller" in the signal-box consists of a plunger, which is drawn out of its cylinder by the signal lever, this action creating a partial vacuum in the pipe and drawing-down plunger in the

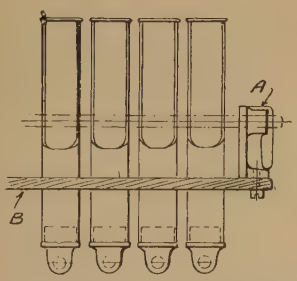


Fig. 257.—Plan of Impellers

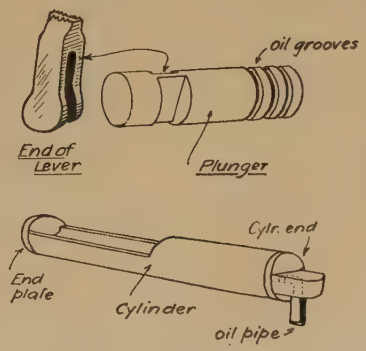


Fig. 258.—Impeller Piston and Cylinder

"motor" on the signal post. It is astonishing how rapidly and over what a long distance the movement can be accomplished. On replacing the signal lever the "motor" will follow the impeller. Any slight leakage in the pistons in the interim between the two operations will tend to assist rather than impair the action. The partial vacuum formed on the forward movement, if destroyed, will result in a pressure in the pipe line when the impeller piston returns to the normal position. There must, however, not be too great a disparity between the impeller and motor-cylinder

volumes. Where the signals are close to the cabin the builder can rely on the longer stroke of the impeller piston to make up for any losses in transmission and for the volumes of the intervening pipes, and may use the same size of cylinder tube for both the impeller and the motor.

The tube connecting the two units need not be more than $\frac{5}{64}$-in. bore, and to eliminate such troubles as would ultimately occur where rubber tubing is employed, a light gauge copper or brass tube, with soldered socket joints, may be recommended for the purpose of transmitting the air pressure. The pipes may be laid either above or below the substructure of the railway.

The cylinders should be of the quality of tube known as triple drawn, or "treblet" tube. This is not necessarily a solid drawn material, but is truly cylindrical, and is employed in making optical and other instruments of a like nature. The impeller tubes should be $\frac{1}{2}$ in. outside diameter, and for the signal-motor tubes $\frac{3}{8}$ in. diameter outside may be used, if it has very thin walls. The caps may be turned plugs, as shown in Fig 256, for the signal-box impellers or pieces of bent plate (e.g., the brackets holding the tube to the signal post) in the case of the motors. The plungers may be of turned brass or steel rod, and should have two or three oil grooves turned in them. They may be lapped into the cylinders with pumice powder. Emery powder should not be employed for this purpose, as it is difficult to remove after the grinding-in operation.

In the signal cabin, illustrated in Figs. 256 and 257, the levers are pivoted to end plates A by a stout steel rod (at least $\frac{5}{32}$ in. for a 10-lever frame and $\frac{3}{16}$ in. for a larger one). The levers may be cast, and if the type of quadrant where the end of the slot for the lever forms a sort of notch out of which the levers are sprung sideways is used, then

ordinary double-spring washers (a commercial commodity) may be fitted on the pivot spindle, as shown at S, to give the levers a lateral resiliency.

To the frames (A) a spectacle plate (B) is fitted, with suitable screws at each end. This plate is drilled to fit the cylinders, the latter being soldered into place. The cylinders are field nearly in halves at one end. This must be carefully done. Rough handling would distort the tube. When the end oil-retaining plates are soldered on, the pistons (see Fig. 258) may be inserted and the air-pipe caps

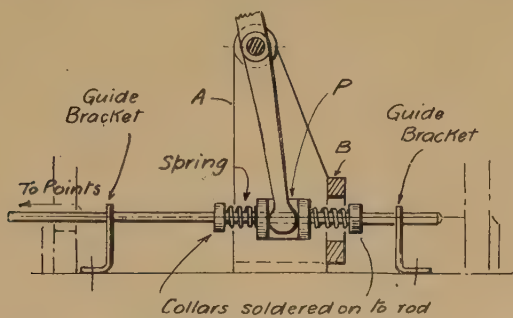


Fig. 259.—Mechanical Points and Levers

soldered in. The end of the levers are forked, and should be an easy fit over the thin webs formed at the outer ends of the pistons, as indicated in Fig. 258.

The cabin is arranged with a removable back and with the back half of the roof to lift off. A double floor is also suggested in case any one of the simple interlocking gears, illustrated in this book, is adopted. Should mechanically-operated points be employed in conjunction with air cylinders, the frame plate B would be drilled with holes for cylinders to allow for possible future alterations, but could be fitted up with the scheme illustrated in Fig. 259. The same levers and method of drive are employed, spiral

springs intervening between the plunger P and the point rod to take up any back-lash in the joints between the signal cabin and the points themselves. The plunger would be drilled for the rod before being filed in the centre to receive the forked end of the lever.

The scheme wherein the movement of the lever creates

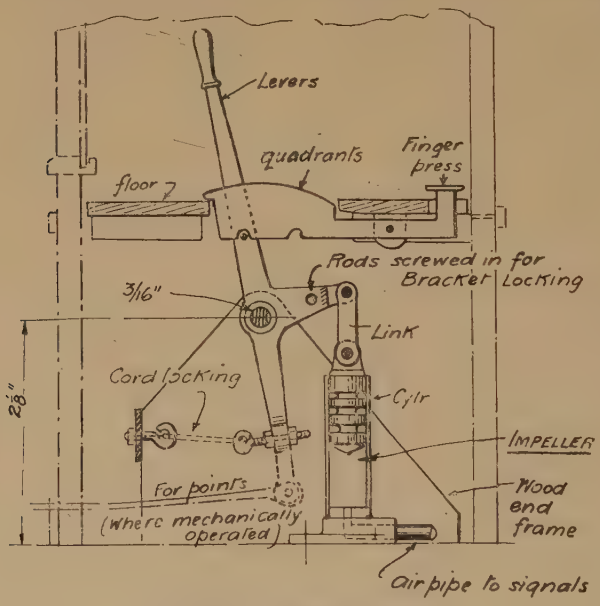


Fig. 260.—Pressure Impeller

a pressure in the impeller and forces the signal-motor piston up or outward, is illustrated in Fig. 260. Here the cylinders are placed vertically, and can be screwed down to the base board of the railway. The levers could be extended, as shown by dotted lines, for mechanically-operated points. A simple method of arranging the catches of the quadrant is also shown. The latter are made up out of sheet, as illustrated in Fig. 261, and are pivoted to the floor,

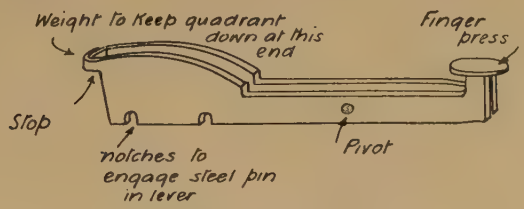


Fig. 261.—Lever Quadrant

or, preferably, to the sides of the cabin, so that their weight keeps them engaged with the short $\frac{1}{16}$-in. pin driven through the lever. On the other side of the fulcrum a finger press is arranged, this "button" projecting through the floor. Cord and bracket interlocking is also provided

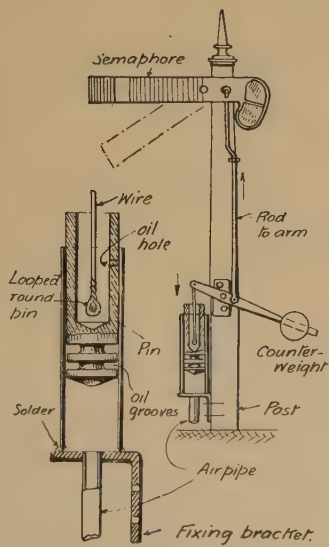


Fig. 262.—Vacuum (Pull-in) Signal Motor

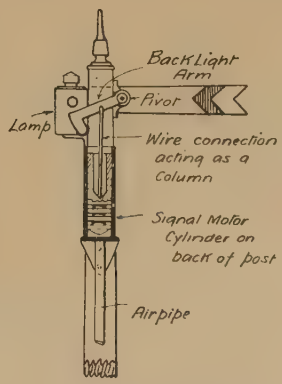


Fig. 263.—Pressure (Push-out) Signal Motor

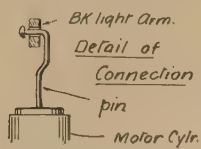


Fig. 264.—Connection of Arm and Motor

for. The brackets could be made of $\frac{1}{8}$-in. steel wire driven and soldered into holes in the bell cranks of the lever. They would, therefore, engage adjacent bell cranks, the outer ends of the bracket wires being set upwards to allow of this.

Pneumatic Signal Motors.—For the suction impeller the motor can be arranged on the signal post, as shown in Fig. 262, this illustration including an enlarged section of the motor cylinder. The usual arm, connecting rod, counterweight, etc., is employed, and to lighten the plunger this is drilled down as far as the grooves, as illustrated. The counter-balance arm is connected by a fine wire, which may be looped round a pin inserted in a hole drilled at right-angles to the bore. The latter recess may be employed to hold the lubricant, an oil-hole being drilled to the outside, as indicated. If the gudgeon-pin is a loose fit in the holes in the piston, this oil-way may be dispensed with, as the pin will then act as a needle lubricator. The lower end of the motor cylinder may be soldered on to a brass bracket, as shown, the latter thereby serving two purposes.

The pressure scheme is illustrated in Fig. 263, which shows the signal motor bracketed at the back of the post near to the arm. The piston is bored out, as in the previous example, and the motion is transmitted to the arm by a stiff wire (a household pin with a sharp bend near the head) which pivots in a hole drilled in the back-light arm, as in Fig. 264. This arrangement has the merit of requiring fewer parts, and in the case of bracket signals and gantries, the only connection with the bottom of the post is the air tube. This can be bent round any corner. From a railway regulation point of view, the failure of any part or the rupture of an air pipe in both designs will return or maintain the semaphore at danger. In the case of the

second (the pressure) device this safety action is, perhaps, more certain.

Taking it as a whole, the model pneumatic signal has great possibilities, and if a reasonably skilful degree of workmanship in the fitting of the motor and impeller pistons is obtained, there is no reason why the size of the motor-cylinder tube should not be reduced to $\frac{5}{16}$ in. This

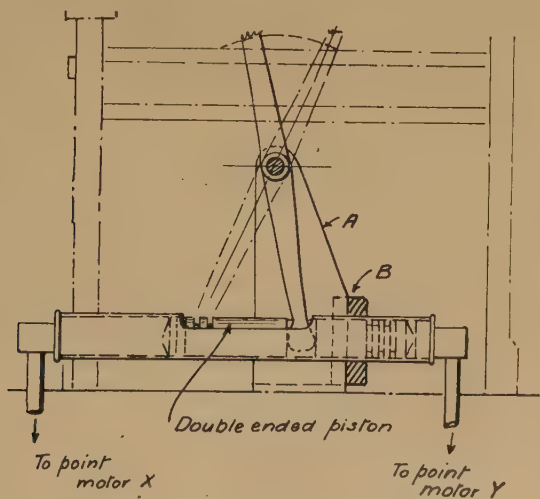


Fig. 265.—Duplex Point Impeller

will tend to produce smaller and neater fittings in a No. 0 gauge model.

Pneumatic Point Operation.—Where the points are of a type which will move with the least expenditure of power, i.e. those having pivoted switch rails or their equivalent, there is no reason why they should not be actuated by an air-line system, such as described for signal working. It would, of course, be advisable to increase the sizes of the impeller and motor tubes, and it would appear necessary to operate points by double-acting pistons. The writer

would suggest $\frac{5}{8}$-in. or $\frac{1}{2}$-in. diameter tube for the motors, and $\frac{5}{8}$-in. diameter for the impeller. There is plenty of available power, and not the least objection to the use of pistons of larger area than those adopted for signals.

Fig. 265 shows a simple method of making and actuating a double-plunger impeller. It requires no further description except to say that it could be easily adapted to the lever frame, illustrated in Fig. 256, and that two pipes are necessary to each point motor. An equally simple point motor

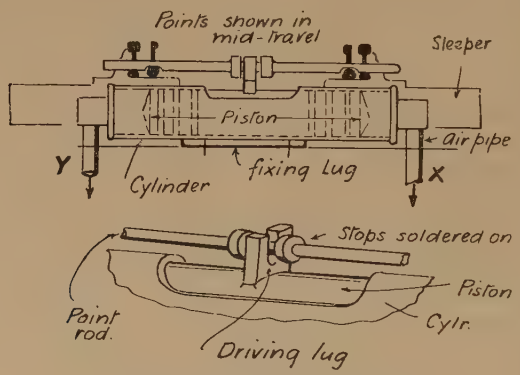


Fig. 266.—Duplex Point Motor

is shown by Fig. 266. The cylinder lays across the permanent way and directly under the switch-rail cross-connecting rod. As in this arrangement the stroke of the motor piston would be small, increased force may be obtained by using $\frac{5}{8}$-in. tube. For the alternative scheme, illustrated by Fig. 267 (in which a lever is introduced), the use of $\frac{1}{2}$-in. tube should be quite satisfactory.

Automatic Lock.— Objections may be raised to either of these motors from the standpoint that the points are not locked when they are set for one direction or the other. To overcome this, the writer suggests, for those model-railway

builders who are particular in such matters, an automatic lock as illustrated in Fig. 268. The lock consists of a hinged flap which drops over the inlet pipe and locks the piston. The rush of air into the cylinder would lift this lock on the impeller being operated. Such a device will require to be well made if it is to be successful. While the flap should be sufficiently light to be lifted by the rush of air, it should be heavy enough to fall over the catch. Further, as much of the cylinder as possible should be

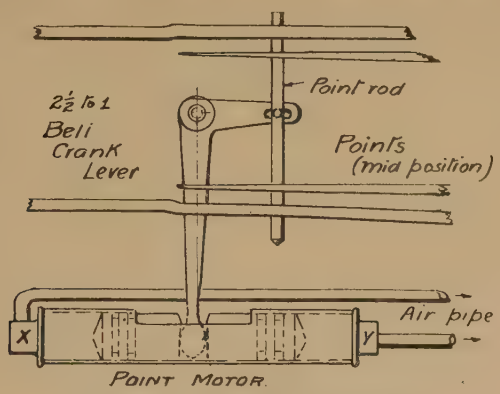


Fig. 267.—Bell-crank Point Motor

occupied by metal, to reduce losses in transmission which would occur if the clearance volumes were excessive.

Electric Signals.—Signals may be operated by solenoids or magnets from a central battery placed in or near the signal-box. One trouble which is experienced in most magnetic model signals is the violence of the action. Some means of damping the movement of the magnet or solenoid is, therefore, desirable, although such devices may be considered in the nature of refinements which are hardly worth the labour involved. In electric signals of the solenoid type, the size of the magnet should be adequate. It cannot

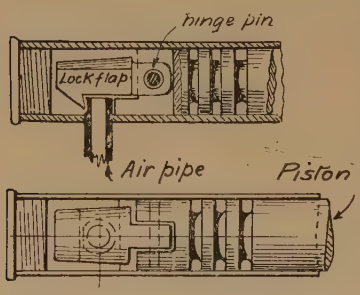


Fig. 268.—Auto Locking Gear for Point Motor

be made to look like any scale fitting, and, therefore, it is suggested that the operating magnets should be fitted below the base of the railway. The operating voltage should be very low, i.e. about 2 volts. This will reduce the size of the motive mechanism, allow a larger gauge of wire to be used, and prevent heating in the magnet coils. Figs. 269 and 270 illustrate two types of electrically-operated signals.

Bracket signals should be avoided, as they introduce difficulties in arranging the solenoids in a neat manner, especially in small indoor models. Fig. 271 shows a solenoid operating a ground disc signal. The weight of the solenoid armature on the end of the rod connecting it to the bell-crank lever returns the signal to danger, on the cessation of the energising current.

Series System of Electric Signals for Model Electric Railway.—This scheme is fully dealt with in a companion volume to this, viz.: "Model Electric Locomotives and Railways." It is applicable only to model electrically-operated or controlled railways. By controlled

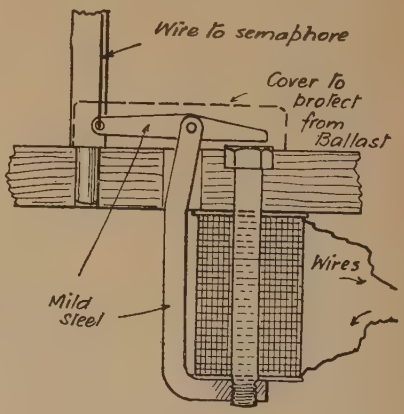


Fig. 269.—Concealed Magnetic Mechanism for Semaphore Signal

railways the author means that although steam locomotives may be used, the line is laid with a conductor rail and the locomotives provided with current collectors and magnetic

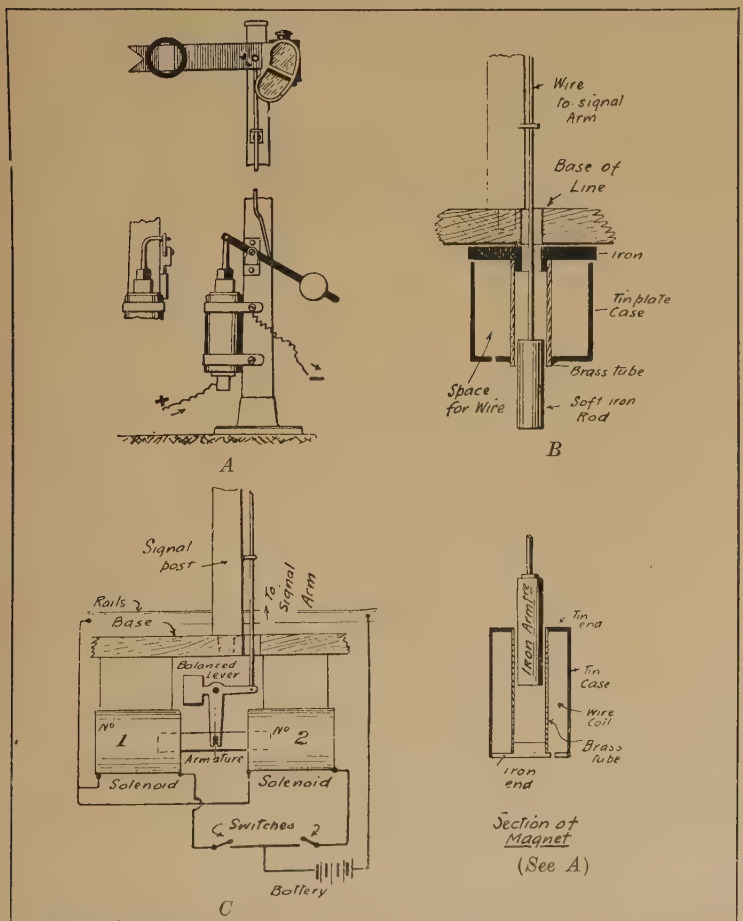


Fig. 270.—(*a*) **Solenoid Signal with Counterweight Return**; (*b*) **Solenoid Signal with Pull-up Action Returning by own Weight**; (*c*) **Each Movement made by Separate Coil**

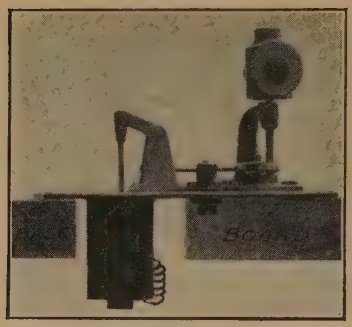


Fig. 271.—Solenoid Type Electric Ground Signal

or motor-control gearing, whereby speed and direction of travel may be governed from a control cabin or other point at the side of the railway. The semaphore signals are operated by the control or power circuit, as the case may be. There are, therefore, visual indicators of the state of the track. When the power is applied and a locomotive occupies that section of the track, the signals take the "off" position. The system is one which involves the expenditure of practically no extra current, the magnetic devices operating the signals being of low resistance and in series with the respective power circuits of the track.

Electro-motors for Operating Points.—In real practice at least one of the "all-electric" systems of power signalling involves the use of the ordinary electric motor for the purpose of moving points. This scheme has been copied in model work, and Fig. 272 illustrates a notable example. The motor drives the crank and connect-

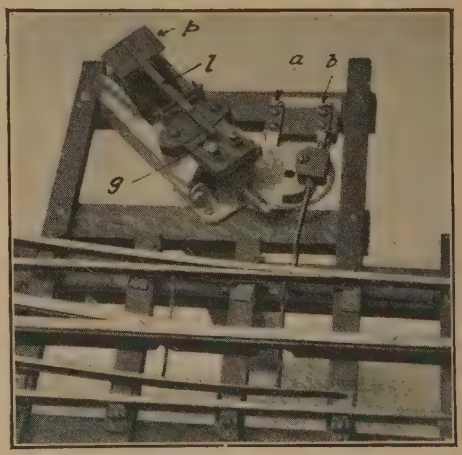


Fig. 272.—Motor-operated Points

ing-rod gear by means of a worm and worm wheel, the latter forming the crank. The electrical switch-lever in the cabin is arranged to engage either one of two contacts, and send a current through one of two wires connected to the brushes *a* and *b*, the return current flowing through the rails. The large gear wheel or crank is pierced with a slot extending through nearly half its diameter, and one brush or the other is cut out of action by this slot, the gear wheel forming the contact between the motor and the signal cabin. When the points, therefore, are moved to a position for the main or

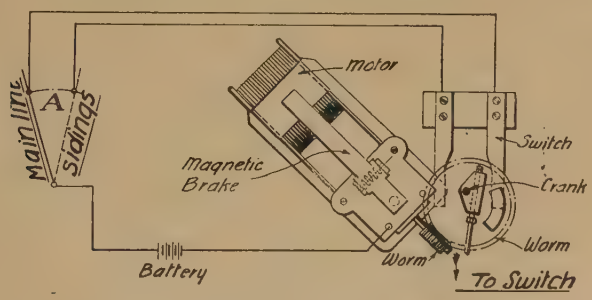


Fig. 273.—Connections of Point Motor

the branch, the current is cut off from the brush which has supplied the current causing the rotation of the motor armature. The cabin lever has, therefore, to be pulled over to the other contact to cause the gear wheel to make another half revolution, and return the point switch to its previous position.

This is, perhaps, more clearly shown by Fig. 273, which also shows the magnetic lock. A motor armature when running at top speed has a store of energy, and will continue to rotate for a short time after the current is cut off. To arrest the armature and to maintain it in such a condition until current is again supplied to the motor, a lever (*l*)

is fitted to the motor, one end of which has a peg (g) which projects down, in between the poles of the armature of the motor. It is removed by the magnetic attraction of the field magnet acting on an iron plate (p) at the other end of the lever. When current is passing through the motor the peg is therefore withdrawn, and the armature is free to revolve.

A Magnetic Point Motor.—In a model railway which the author built for an exhibition the points were operated

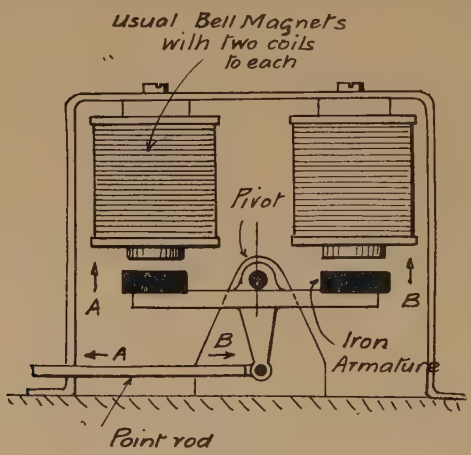


Fig. 274.—Magnet Point Motor

automatically by two separate large bell magnets (Fig. 274). These were concealed inside a model platelayer's hut. The armatures were fixed on a pivoted support and each set of magnets moved the points its own way. The points were made with the switch rails pivoted so that an extremely small current was required to move them, there being ample iron in both the magnets and the armature. The points, however, moved with very little resistance. In the case where the current was arranged to pass through the magnets during the whole time the locomotive and train

was passing over the points, no trouble was experienced, but in another instance the points were free of restraint.

A simple spring lock (Fig. 275) was, therefore, arranged mechanically to hold the points in the position to which they had been moved by the action of the electro-magnets. Of course the friction of this device added to the work required from the magnets, but quite a small force was found to be necessary to prevent the rattle of the trains moving the point blades. Two notches were employed at each end of the stroke to allow for errors in adjustment.

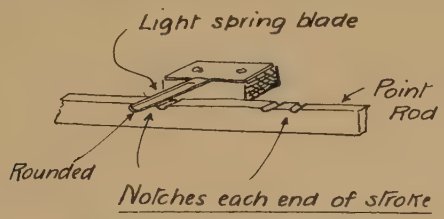


Fig. 275.—Point-locking Device

Solenoids for Operating Points.—Fig. 276 shows a double-acting solenoid which is satisfactory for moving points with pivoted switch blades. A soft-iron casting can be employed for the carcass of the point operator, the piece of soft-iron rod forming the solenoid magnet being arranged to slide in a brass tube on to which the "former wound" coils are threaded. The iron end-caps are then fitted in and the magnetic arrangements are complete. The total movement of the solenoid should be, at least, twice that required by the switch blades.

A magnetic lock, which must be in series with both solenoids, may be adopted if the scheme illustrated in Fig. 276 is adopted. With such a motor the magnetism of the solenoid carcass would not, normally, operate a lock of the kind illustrated in Fig. 273.

As will be observed in the diagram of connections (Fig. 280) a magnetic lock is best placed in circuit with the return wire, which, by the way, is common to both solenoid coils. As shown in Fig. 277, the lock magnet is a small bell magnet (two coils) fitted on top of the iron carcass of the point operator. This magnet attracts an iron or soft-steel armature, and lifts the ratchet fitted to the

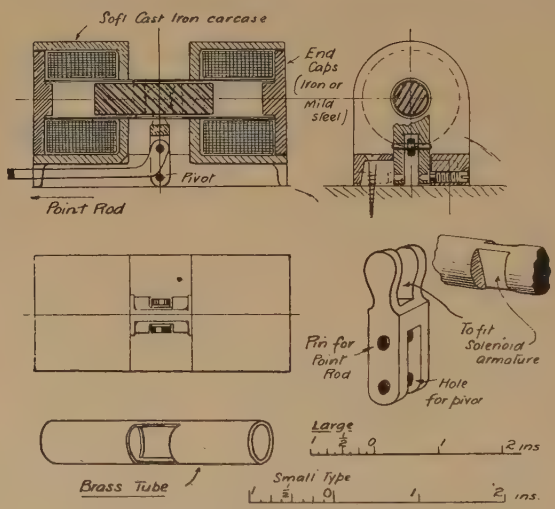


Fig. 276.—Solenoid Point Motor

underside of the armature out of mesh with the thin strip of spring steel fitted to the side of the lever. The lock armature is also mounted on a piece of thin clock-spring fixed at one end to the carcass. The tendency of the spring (and the weight of the armature) will be to keep the ratchet in mesh with the lever and hold the points in either the forward or backward position. The mechanism can be made in two sizes, 3 in. long for small lines and 4 in.

long for No. 1 to 2½-in. gauge railways. Scales for each are provided in the illustration.

It is presumed that the action of a solenoid is under-

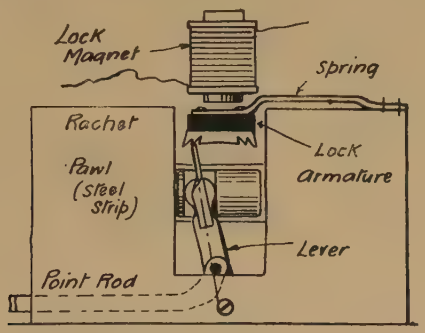


Fig. 277.—Lock for Solenoid Point Motor

stood. Briefly, it may be stated, any energised coil of wire will attract an iron bar into it, with a force which is proportionate to the current strength and the number of turns of wire in the coil. Sufficient iron is also necessary, and,

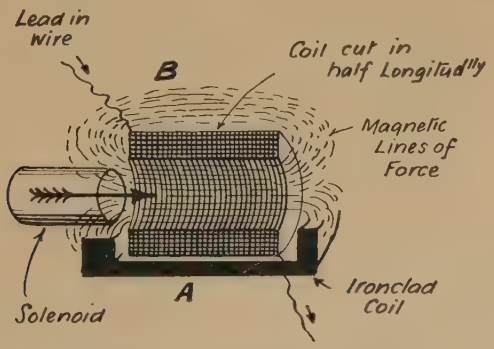


Fig. 278.—The Action of a Solenoid

further, it is highly important that the magnetic circuit should be enclosed by iron, so that the "lines of force" travel through this iron without resistance (sectioned black

at A in Fig. 278), instead of struggling through the air, an inefficient medium, as indicated in the upper part (B) of the diagram. The coil is shown in perspective sectioned longitudinally. The direction of the energising current has no bearing on the movement of the armature. The latter always wants to enter the coil. The design, as shown, also presumes that a casting will be made to form the duplex solenoid. If only one such mechanism is required it will obviously be cheaper and easier to build up two solenoids on a block of wood. Wrought-iron gas-tube sockets and washers may be employed for the purpose of making the iron carcass over the coils.

Switch Lever for Points Operated by Momentary Current. — One feature of electrical mechanisms for moving points and similar devices where the current need only flow for a short period—long enough to accomplish the desired operation—is that special means will have to be provided in the switch lever to cut off the current when it is released. In the solenoid and magnetic operating devices (Figs. 269, 270, 276 and 279) the lever should, on being placed, say, on No. 1 contact (see Fig. 280) spring back to position 1a when it is released. The same will apply when it is moved to the opposite side; it will spring back from No. 2 to position marked 2a in the diagram of connections. This method of arranging the lever will give an indication in the cabin of the position of the points outside, and also provide for the ordinary lever-interlocking gear, if such is fitted or required.

Electric Buzzer as a Point Motor.—As electric motors are expensive items the device shown in Fig. 281 is worthy of experiment. The motive mechanism consists of an ordinary magnetic buzzer or the parts of an old electric bell, and it is adapted to the purpose of point moving by

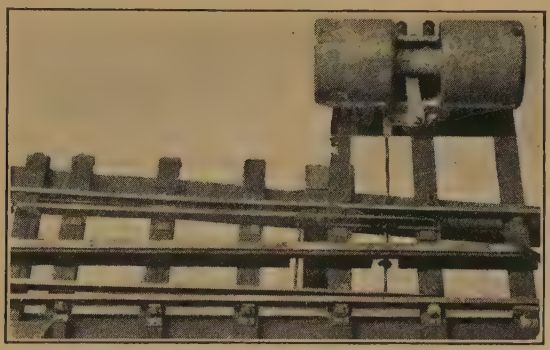


Fig. 279.—Photographic Reproduction of Solenoid Point Motor

fitting the vibrating armature with a light spring pawl, BL, which actuates a ratchet wheel with very fine teeth. This wheel is fitted with a crank-pin to which the connecting rod is attached. The other end of the latter is fitted to the points, and if the running rails are employed as one of the conducting wires for the power circuit, then the point rod must be insulated from the motive mechanism

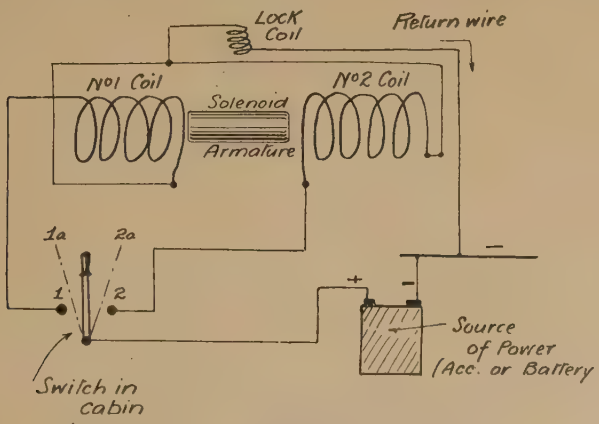


Fig. 280.—Connections of Solenoid Motor

somewhere in its length. This insulating block is, in Fig. 281, shown holding the contact brush.

As the rotary movement of the ratchet wheel must be converted to a reciprocating one, the half revolution of the wheel from A, through B to A will close the points as indicated by the arrow. At A the power should be cut off. The rubbing point of the contact brush will, in the present arrangement, take an elliptical path, and will cross from

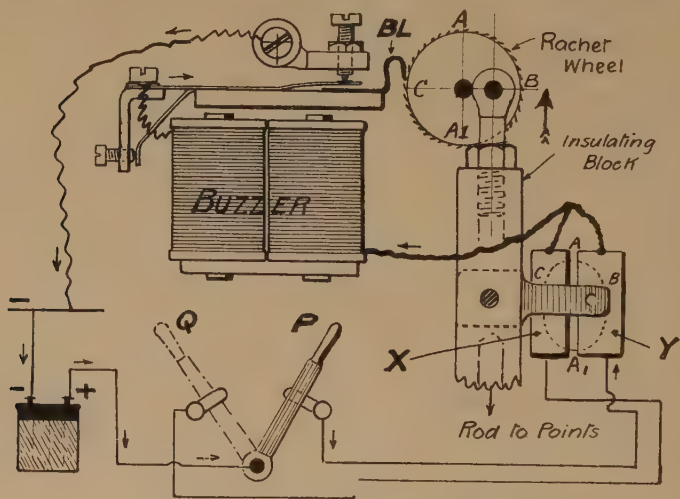


Fig. 281.—Buzzer Motor for Points

contact strip Y to strip X. The points will, therefore, be closed and the movement of the point motor will cease. It will only resume when the lever is moved over from P to Q. The wheel and contact strip will then move from A, through C to A1, and close the points in the opposite direction. The details of the contact strip and contacts are illustrated in Fig. 282. Points require power of varying magnitude—the amount is only to be found by experiment—and, therefore, the simple arrangement shown in Fig. 281 may necessitate

a much larger buzzer than could be got into the space the builder would prefer. As illustrated, a ½-in. wheel with about 50 teeth is used, the crank pin being placed at ⅛-in. throw (i.e. ¼-in. travel). This size was chosen as such wheels are used in cheap pocket petrol lighters.

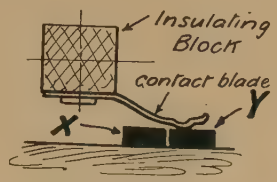


Fig. 282.—Contacts for Buzzer Motor

Where more force is required the wheel must either be larger in diameter, as shown in Fig. 283, or a small ratchet wheel may be employed and fitted on to a spindle which has a pinion suitable for gearing into a larger-geared crank disc. Possibly some old clock parts could be pressed into service to make this portion of the mechanism. This scheme is illustrated in Fig. 284. The spring steel blade BL from the pawl of the device should be carefully adjusted

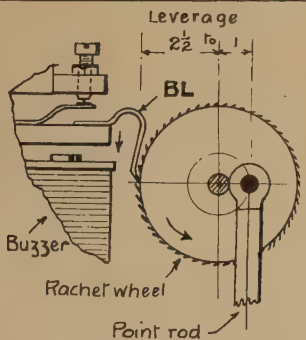


Fig. 283

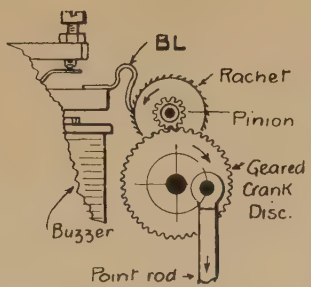


Fig. 284

Figs. 283 and 284.—Gearing for Buzzer Motor

so that it will not drag the wheel round on the backward stroke.

In effect, this buzzer device is similar both electrically and mechanically to the electric motor mechanism already

described, but the absence of a rotating armature will render the use of the magnetic lock unnecessary. Further, a small buzzer will only involve a cost of about one-fourth that of a motor, and will consume less current.

Electric Slotting.—The necessity of "slotting" signals (i.e. a system of controlling one arm by two signalmen used on full-size railways) commonly occurs. One method of doing this mechanically is shown in the last chapter. Where power signalling is accomplished by electricity it is

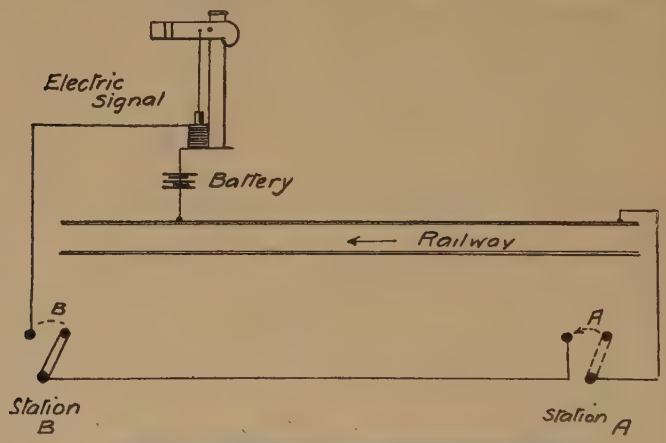


Fig. 285.—Electrically-operated Semaphore Signal

very easy to arrange the switches, as shown in Fig. 285, so that it requires the co-operation of two men to bring the semaphore arm to the "line clear" position.

Automatic Signalling and Track Circuiting.—The system of signal and train control based on track circuiting is much used on modern railways. Fig. 286 explains the scheme. Between each control section one rail is electrically broken, and if a potential is maintained between opposite rails by a suitable battery the presence of a train on any section will short-circuit the rails and break down

that potential. Conversely it is also possible to close a circuit through the wheels and axles of the train resting on the section of track-circuited railway. In the diagram the railway is arranged so that all signals remain at "line clear" when no train is occupying a section, but when a train as at A is short-cutting that section it places the entering signal No. 1, from section *a*, at danger. When the train proceeds to B it will do the same to signal No. 2, but will free No. 1, so that the following train can proceed from *a* to B.

Fig. 286.—Track Circuiting

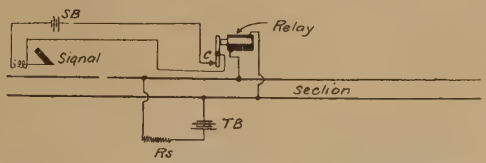


Fig. 287.—Auto-Signalling by Track Circuiting

Fig. 287 shows how this can be accomplished. The opposite rails are connected by a track battery (T B) and a high resistance (R S). This energises the relay, closes the contact C, and maintains the entering signal at the "off" position, indicated in the sketch. A train in the section would short-circuit the track battery, and the contact C, which may be released by gravity or a light spring, would then break the signal circuit. This would return to danger by its own weight and stop the train.

While the above is an ideal scheme, from the point of view of the engineer of a full-size railway, in that any

electrical failure would cause the signal automatically to return to its safe position, i.e. showing "danger," it necessitates a considerable expenditure of current. This may not be convenient. Of course the track battery need only consume a very small current, while all the signals on a complete line could be energised from a common battery. The arrangement shown in Fig. 288 is one in which the signals are normally "off," but are maintained at danger, electrically, by a train in a previous section.

The train BX is causing a current to flow through No. 1 signal solenoid and keeps it at "danger." No train being present in CX the signal No. 2 falls to the "off" position, showing that the section is free. This is not orthodox, but there are no lives to lose on a model railway.

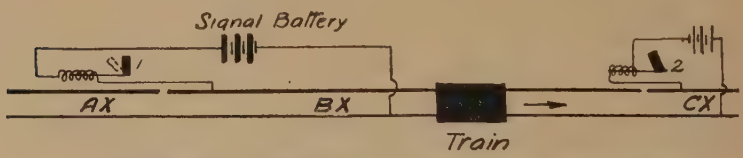


Fig. 288.—A Simple System of Electrical Auto-signalling

Where a section of an indoor line is inaccessible, or in a tunnel, such a scheme of automatic signalling may be applied without interfering with that used on other sections. Further reference on this point should be made to the companion volume already mentioned.

Electrical Notes.—In designing electrical signals the amount of current that will be impressed on the coils of the various magnets employed is an important factor. The current density in the wires should not exceed 1000 amperes per square inch, otherwise there will be danger of overheating and fire. Tables of the ohmic resistance per unit of length of various insulated wires, together with data

as to the space occupied by such wires in magnet coils, are included in the notes on electro-motor design in the author's "Model Electric Locomotives and Railways," uniform in style and price with this volume and obtainable from the same publishers. As already stated, the subject is one requiring careful consideration, and the volume in question exhaustively deals with all aspects of the matter, the special application of the information being given in this chapter.

CHAPTER XII

Bridges for Indoor Models

Model Culverts—Where railway lines cross small streams and watercourses, what are called culverts are employed. These are small bridges with arches of various forms. In some cases the brickwork tunnel forms a complete ring, making a sort of sewer under the track. Some excellent model bridges are illustrated in this book. For model railway purposes the design shown in Figs. 289 and 290 is applicable, and it only requires a depression in the formation level of about $1\frac{7}{8}$ in. in No. 0 gauge. The sides of the

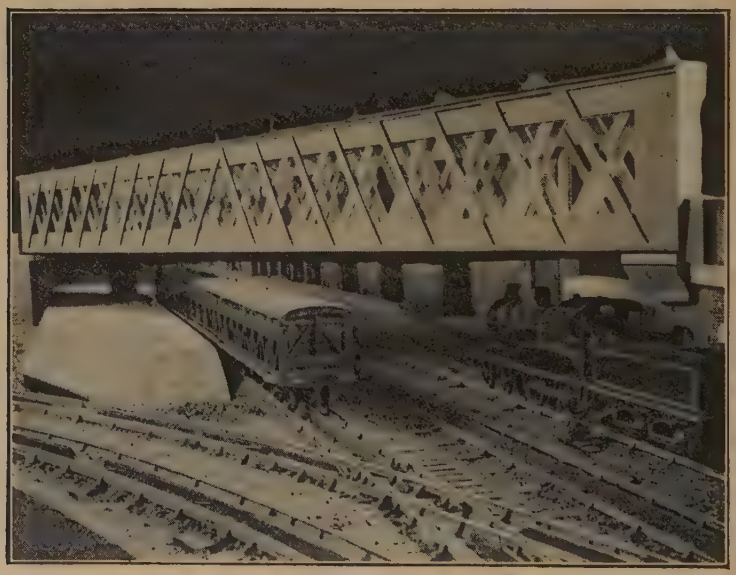


Fig. 288a.—Mr. E. H. Foster's Model 2-in.-gauge Lattice Girder Bridge

culvert should be made out of $\frac{3}{8}$-in. board (mahogany or other easily-worked wood of close grain), which, after being cut out to shape, have planted on to them the $\frac{3}{16}$-in. by $\frac{3}{4}$-in. section piers, the string courses ($\frac{1}{8}$ in. by $\frac{1}{16}$ in.), and the copings. The latter are formed out of $\frac{1}{2}$-in. by $\frac{3}{16}$-in. strip wood, and are chamfered on the top, as indicated in the sketches, to represent the weathering of the stone cappings of an original bridge. The sides are nailed or screwed to a stout floor board, or if the latter is a part of

Fig. 288b.—A Bridge on Mr. H. R. Ward's Model No. 1-gauge Railway

the substructure of the railway, then the finished sides may be panel-pinned on to the edges of this floor after they are finished and painted. The angle-blocks shown may be used at each pier to form a better connection between floor and sides. They, however, are not important, and can be displaced by a simple rectangular cross batten.

For a more adequate depression, say 3 in., a culvert or bridge of the type shown in Fig. 292 may be adopted. This has an extra set of abutment piers, but except for this difference the construction is the same as that of the preceding example.

Model Under-bridges.—Railway construction involves the building of bridges over rivers and roads, and, where the level of the line is lower than that of the surrounding country, for the convenience of adjacent land-owners (or occupiers), under-bridges, known as "occupation" bridges, as well as similar road bridges, are required. Road bridges vary in width from 25 ft. to 35 ft., but "occupation" bridges are often made with a clear way of about 12 ft.

Fig. 293 is based on the type of bridge used on the

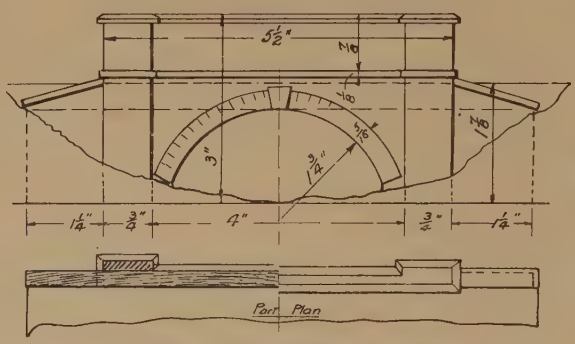


Fig. 289.—Cross-Section of Culvert

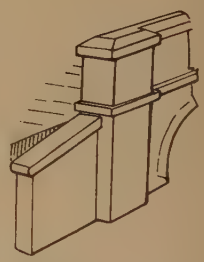


Fig. 290. — Abutment of Culvert

London extension of the G.C.R., and is intended to represent a brick structure with stone copings. The brick-wood supplied by model dealers—which is planed thin wood, indented to represent brickwork—may be employed, on the faces at least, if not throughout its construction.

There is no great scope for such bridges on a small indoor railway. In the corners of a room not occupied by a station or other important feature, the surface of the "land" may be treated in such a way that a bridge of this kind can be introduced. In Fig. 294 the pathway over the bridge may be made to slope up and down from the level

fields on either side. Or, as in Fig. 295, the ground may be raised so that the railway is running in a cutting at this point. The abutment wings would have to be arranged to suit the slope of the ground in each case. In fitting up to the plan shown in Fig. 295 the slope at A could be flattened out somewhat, and the wings of the abutment would, on this side, be placed more or less parallel to the railway, with an arrangement such as is shown in Fig. 296 on the opposite side, an extra pair of piers being fixed at the top of the cutting. In both cases fencing can be introduced as at *f n* (Fig. 293) to enhance the effect of realism.

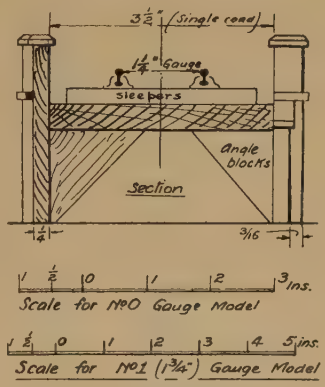


Fig. 291.—Cross Section of Culvert

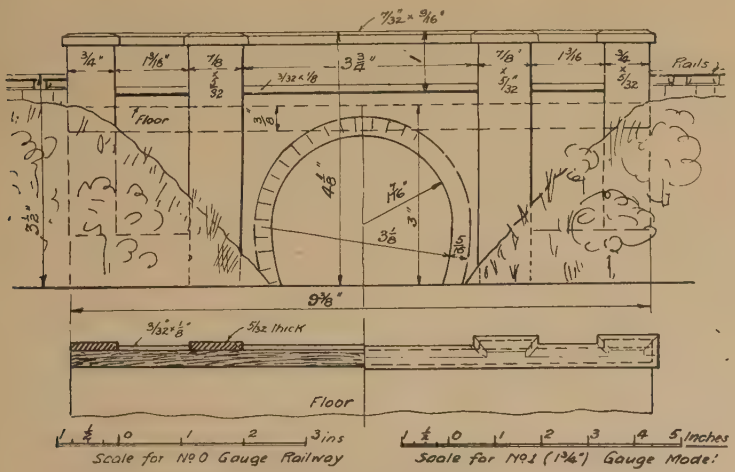


Fig. 292.—Large Culvert

The elevation of the bridge where the road slopes up on each side is shown in Fig. 293, the sectional view (Fig. 297) explaining its construction. For the main abutment piers two blocks of wood (x) are prepared to the dimensions given in Fig 293, the faces being rebated $\frac{3}{8}$ in. to take the side walls or arch pieces *r*. When cut to shape

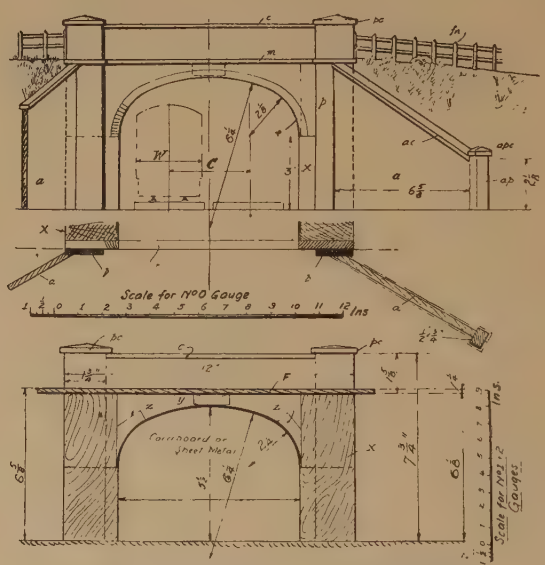


Fig. 293.—Double-road Under-bridge

the latter are screwed on to the pier blocks. It will be noticed that the inside faces of the piers are cut back above the springing line of the arch to the extent of $\frac{1}{16}$ in. to receive the cardboard or sheet-zinc lining of the arch. Strips or packing blocks are used, as shown at *z* and *y*, to form a fixing for this lining. The parapets are two pieces of wood *p t*, which rest on the arch pieces, and are secured

to the floor (*f*) of the bridge. The strips *m* are string courses to mask the joint, and to improve the appearance of the bridge, *c* being similar but wider strips forming the parapet coping. The projecting piers *p* are nailed on to the abutments and parapet, the "weathered" capping *p c* surmounting these piers and the parapet.

A bridge of this kind should always be quite clear of the loading-gauge dimensions, which are indicated at c and w in Fig. 293. When finished the work should be painted in flat colours, brick red, with stone-colour cappings. The

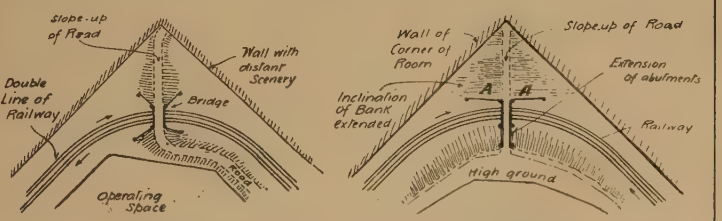


Fig. 294 Fig. 295

Figs. 294 and 295.—Setting of Occupation Bridge and Earthworks

sloping abutments are made of thin wood, as shown, and finished with small imitation stone-capped piers.

On many lines—the L.N.W.R. in particular—the under bridges are often made of steel box girders. These can be modelled in wood quite easily. The side girders are simply beams of thin wood with vertical and horizontal strips glued and pinned to them. These beams are, in turn, pinned or screwed to a floor forming the surface of the road. In Fig. 298 the model bridge is shown carrying a line of railway across another.

Model 3-span Bridge for Indoor Line.—The model 3-span viaduct (Fig. 299) is designed for a No. 0-gauge

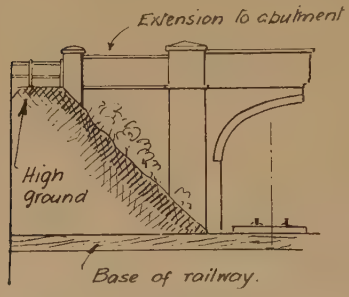


Fig. 296.—Alternative Form of Abutment

railway, and is intended to bridge a depression $5\frac{3}{8}$ in. deep and $26\frac{1}{4}$ in. long. Both these dimensions are easily capable of adjustment to suit the specific requirements of the reader, while in width it would create no difficulties if the viaduct were made for a 2- or 3-road track. The piers could be made hollow instead of solid, and the track for a wide bridge would be laid on a floor built up of a number of pieces of wood with the grain running transversely.

The piers are blocks of wood shaped out of pieces planed up to a net size of $1\frac{9}{16}$ in. by 4 in., the upper portion being notched $\frac{3}{8}$ in. at the sides to accommodate the sides or spandrils of the arches. As drawn, the floor is a continuous plank, and when fixed should have a rebate exactly the same width as the thickness of the parapet wall, which, by the way, is also continuous. The parapet is secured by the projecting piers, which are strips of wood $\frac{1}{4}$ in. thick and $\frac{15}{16}$ in. wide. A string course moulding ($\frac{5}{32}$-in. square strips of wood) covers the joint. The

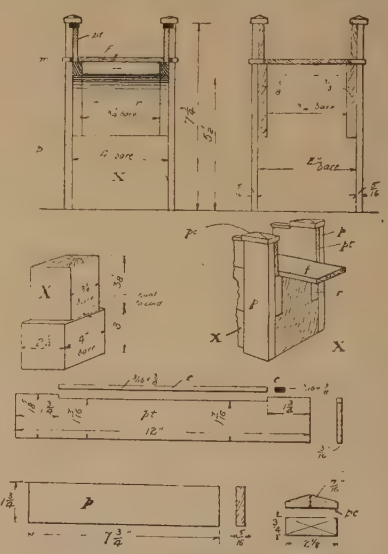


Fig. 297.—Details of Bridge

string course may be returned round the piers, as shown, or it may stop against each of the piers. This will save some constructive work and may look quite as well.

The under sides (the soffits) of the arches may be filled in, if it is thought worth while, with sheet metal or cardboard, suitable fixing blocks being provided, to which this lining may be attached by small nails (or panel pins) and glue. This sheeting may certainly be omitted where the archways are not likely to be viewed from below their level. The keystone is a small piece of thin wood glued on

Fig. 298.—Overline Bridge (L.N.W.R. Pattern)

to the top of the arch. The arch stones may, of course, be indicated by scribed lines.

Lattice Girders in Wood.—If several girders of the small wooden-lattice type are to be made, then the jig method of construction should be adopted. The outline of the various members are carefully set out on a stout baseboard, and hardwood blocks are fitted into the spaces between the girders and outside the piers and longitudinals, as shown in Fig. 300. Some of these blocks may require to be higher than others to retain the strips of wood laid between them. Further, local strips may require to be fitted into the bottom of the grooves formed by the blocks,

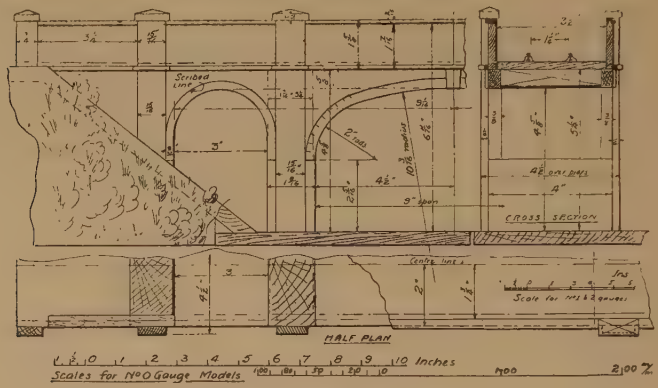


Fig. 299.—Three-arch Viaduct

where the members, which may be laying in a plane above the surface of the base-board, require support during the operation of driving the panel pins. If the parts are glued as well as pinned the jig may be oiled to prevent the glue sticking the girder to the jig. The glue should be sparingly used. For a small model the piers may be built up out of separate pieces or made solid and grooved for the lattice and longitudinal strips before being dropped into the jig. Fine panel pins of suitable length would be employed to join the parts. If necessary, these can be clenched over on a block of iron after the girder is lifted from the jig.

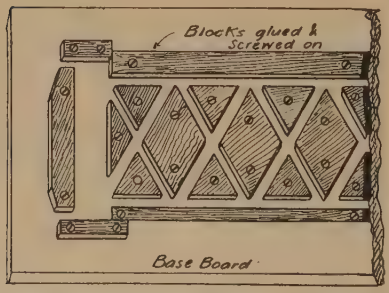


Fig. 300.—Jig for Making Lattice Girders

Model Plate Girder Bridges.—If the making of a large model bridge of two or more spans is intended the labour involved in making lattice girders

may be saved by building the spans to represent plate girders. For the sides of the girders pieces of $\frac{1}{4}$-in. or $\frac{5}{16}$-in. close-grained wood about 15 in. long and $3\frac{1}{4}$ in. wide are shaped out to the nett sizes, shown in the drawing, i.e. to an amount less the thickness of the $\frac{1}{16}$-in. beading strips pinked on to the edges of the girder. Vertical strips of as small a section that the maker can plane the wood down to are glued on to the sides of the girder as shown. The latter are then pinned or screwed on to the floor board, the

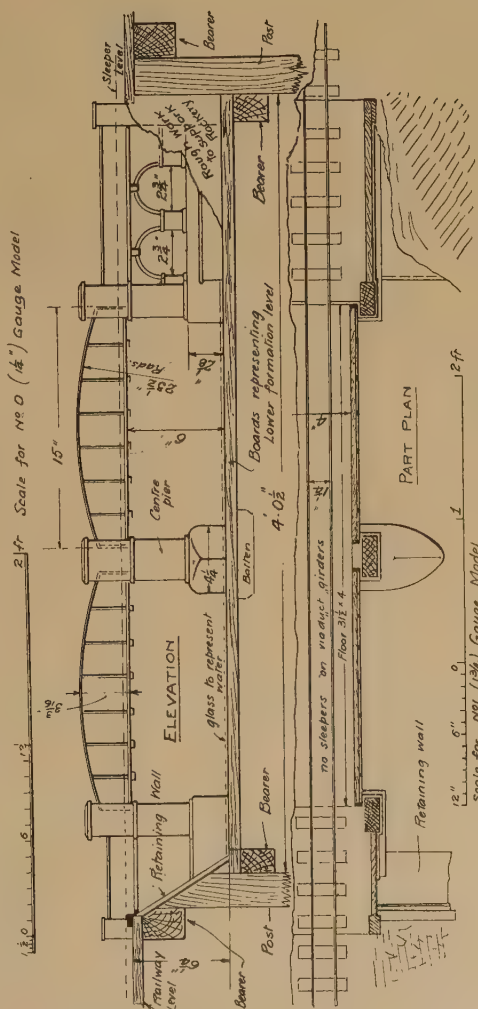


Fig. 301.—Plate Girder Bridge

under sides of this floor having cross strips glued and pinned on to it in the position shown. The piers and abut-

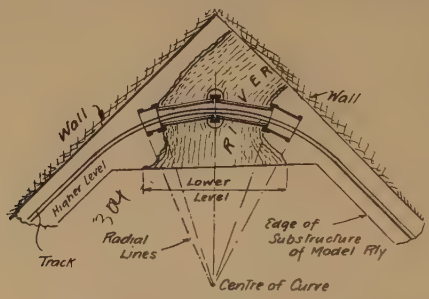


Fig. 302.—Setting for Bridge

ments are separate structures, the construction of which is similar to the others previously illustrated. The rails may be laid on the floor of the girder portion of the bridge, with-

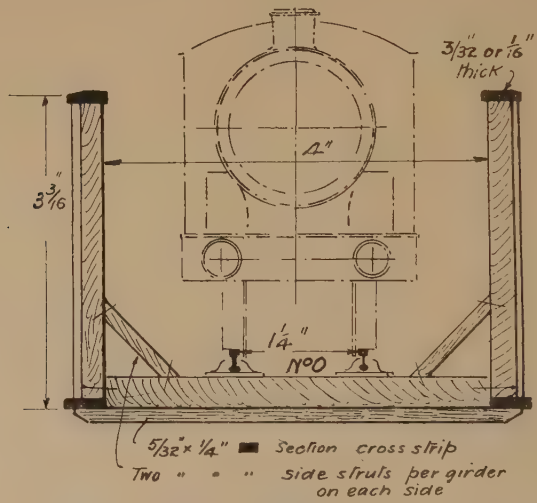


Fig. 303.—Section of Bridge for No. 0 Gauge

out sleepers, before it is built up. On the abutments it will pay to use sleepers, the chairs and sleepers being previously

threaded on to that part (if any) of the length of rail which is fitted to the viaduct floor.

One end of the bridge (see Fig. 301) is shown treated differently to the other. On the left hand the drop in the ground level is masked by a retaining wall; on the right a longer arched abutment, with a rising slope in the ground, is shown. A wharf side is also indicated. As much foreground as the space available will allow should be provided, so that the effect of a broad expanse of water is obtained. If glass is not used to represent the river, the

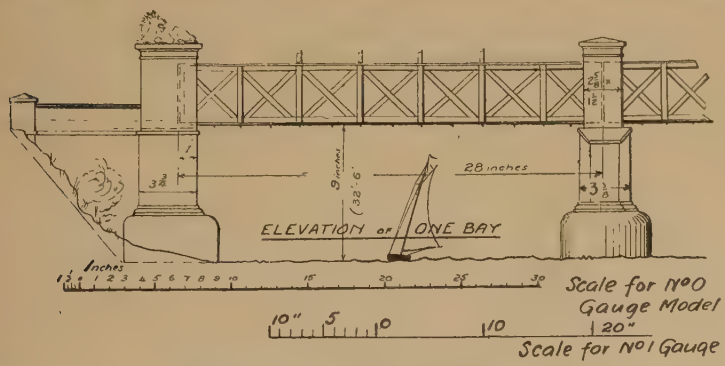


Fig. 304.—Design for Large Bridge

surface must be treated by a paint. This may be varnished with a clear varnish to make it as shiny as possible.

If the bridge is required across a corner of a room and the line is curved, then the floor of the bridge must be made so much wider to allow for the curve and the length of the outer girder increased in proportion to the radius of the curve. The piers must also be set out radially to the curve, as shown in Fig. 302. These dimensions are best determined graphically, say, by a quarter-scale plan on paper, or by a full-size setting-out on the job, the radius of the curve being drawn on the surface of the substructure

boards by a long trammel, such as was recommended in the instructions on track laying.

The span, of course, may be shortened slightly, but this should not be overdone, or the appearance of the bridge will be spoiled; 14 in. would be the minimum span that the author would recommend for a No. 0 ($1\frac{1}{4}$-in.) gauge line. Should there be room the bridge can be enlarged in all its main dimensions. These may be obtained by using the No. 1-gauge scale included in the illustration. The overall width of the girder and the scale of the details,

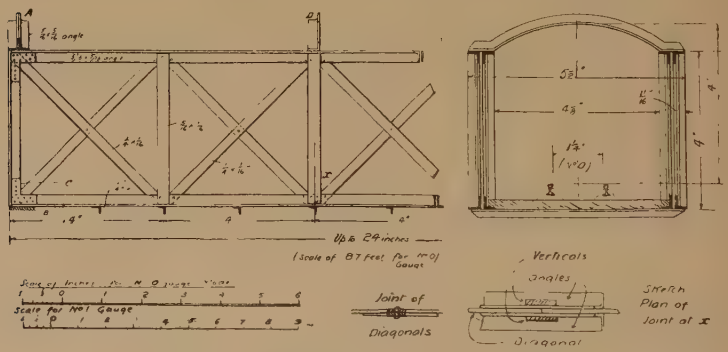


Fig. 305.—Metal Girders for Large Bridge

such as string courses and pier cappings, would be the only exception in this procedure.

A Large Metal Girder Model Bridge.—Although many model railways are arranged to span "yawning chasms," the constructors are more often content to bridge them by a plain deal board, which is sometimes edged by a parapet representing a box girder of an impossible depth compared to the distance between the piers. Or in a railway where the engineering features are more closely studied a lattice or bow-string girder may be arranged on each side of the line at the edge of the aforementioned deal board.

While this kind of construction may be quite good until the line, with regard to its general lay-out is com-

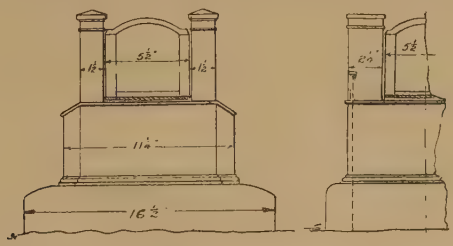


Fig. 306 Fig. 307

Figs. 306 and 307.—Cross Sections of Bridge

pleted, the author would recommend, as soon as time permits, a more pretentious model-engineering structure.

The design for a large bridge (Fig. 304) is an advance on the three-span viaduct, illustrated in Fig. 301, and it is intended for positions where single spans, of the scale

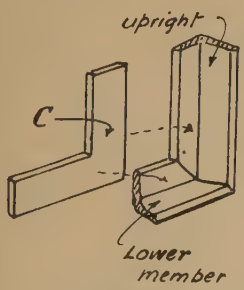


Fig. 310

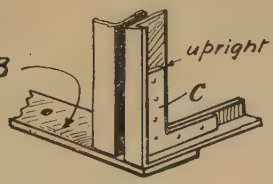
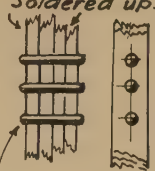


Fig. 309



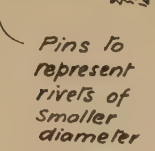


Fig. 308

Figs. 308 to 310.—Metal Girder Details

equivalent of 80 ft. to 100 ft., would look well. Two or three single spans of this length, as suggested in the drawing, would, of course, make a much more imposing struc-

ture. Another point about the construction of a model girder bridge, such as suggested in the drawings, is that the cost of the material is very small, and the amount of skill required in the construction is less than that necessary to build, say, a model clockwork locomotive or model goods brake van.

The whole of the metal required for a No. 0-gauge bridge is standard raw material (angle and drawn-strip brass). The work involved in building it up consists of cutting off the lengths accurately, drilling holes for rivets, and riveting and soldering the pieces together. Indeed, soldering only is necessary at the outset, and rivets can be indicated and the structure strengthened by drilling the joints after they are soldered up and then fitting short pins into the holes. These pins would not be riveted over, but would be allowed to project. When fixed the whole joint would be re-sweated up with soft solder.

The design for the bridge girders is not intended to be an exact replica of any particular structure. In fact, the truss and girder arrangement would be an impossible one if enlarged to full size. However, it is sufficiently representative of real practice, and, at the same time, is comparatively easy to make. A strictly accurate model of a large girder bridge to so small a scale would be the "work of a lifetime" of a skilled mechanic.

The sub-structure of the bridge would, of course, be made of 9-in. or 7-in. deal boards. This would form the arm of the sea or large river being bridged, and could be treated in several ways. The surface could be covered with a piece of glass of the muranese variety, laid with the pattern downward. At the abutment of the bridge the base could be arranged to rise at an angle, in the usual way, to the normal formation level of the line. A rise of just

over 9 in. would in an 0-gauge model represent a scale equivalent of about 32 ft. 6 in. clear height above the water level. The piers and abutments are best made of wood, and are simple box-like structures with suitable cappings and string courses, the general proportions for which may be taken from the illustrations. The abutments are shown surmounted by a recumbent, but aggressive-looking lion. Possibly some such model can be obtained. If applied to a bridge of this kind they make it reminiscent of Robert Stephenson's famous Britannia bridge across the Menai Straits. The proportions of the abutments can, of course,

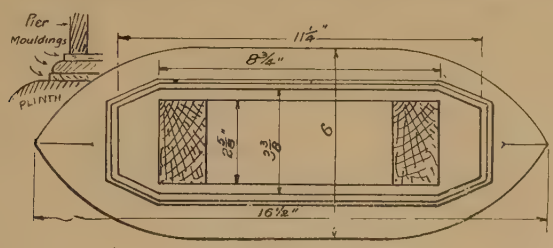


Fig. 311.—Plan of Piers

be modelled to suit the particular piece of sculpture obtainable.

The intermediate piers, the number of which depends on the total length of the bridge, may be similarly constructed, and, if there is sufficient depth, the piers may rest on long plinths of pointed form, as shown in one of the plan views. The mouldings on top of this plinth may be formed of a number of layers of wood of suitable thickness, each piece being cut out to the shape required and laid on top of the other, the upper thinner pieces being square edged and the centre thickness being rounded off to form a moulding.

The bridge girders would be 4 in. or 4½ in. wide inside

for a single line of railway, or 7 in. wide for a double line; No. 0 gauge in both cases. The material required for one 28-in. span, single-line, No. 0-gauge girder would be as follows:

8	pieces	$5\frac{3}{4}$ in.	long.	$\frac{5}{16}$ in. by $\frac{5}{16}$ in.	brass angle.
8	,,	28 in.	,,	$\frac{5}{16}$ in. by $\frac{5}{16}$ in.	,,
8	,,	4 in.	,,	$\frac{5}{16}$ in. by $\frac{5}{16}$ in.	,,
13	,,	$5\frac{1}{2}$ in.	,,	$\frac{1}{4}$ in. by $\frac{1}{4}$ in.	,,
2	,,	$5\frac{1}{2}$ in.	,,	$\frac{5}{8}$ in. by $\frac{3}{32}$ in.	flat brass strip.
24	,,	4 in.	,,	$\frac{5}{16}$ in. by $\frac{1}{16}$ in.	,,
28	,,	$5\frac{1}{2}$ in.	,,	$\frac{1}{4}$ in. by $\frac{1}{16}$ in.	,,

1 piece No. 18 S.W.G. brass plate, 6 in. by $\frac{3}{4}$ in.

All this material is stock stuff and can be readily obtained from any metal merchant. For a larger model (No. 1 gauge) $\frac{3}{8}$ in. by $\frac{3}{8}$ in. and $\frac{1}{2}$ in. by $\frac{1}{2}$ in. angle would be used. The first procedure after cutting the main booms and end uprights to the right length, is to build them into oblong form. This is done by fitting the angle, out of the No. 18 S.W.G. brass strip, into the corner and soldering the parts together. When the two frames forming one side are made up they may be placed in relative positions, one angle turning outwards and the other inwards, and the diagonals (which would have been previously cut out to size and riveted together in the centre in pairs) soldered in place. Although the ends of the diagonals at C (Fig. 309) should be well tinned, and the diagonals lapped over each other at the centre, no soldering should be done here until the whole girder is sweated up after the rivets are inserted (see Fig. 308). The verticals are laid on outside, and are best fixed after the diagonals are fitted with the dummy-rivet pins. This pinning holds any parts already fixed together, while further members are soldered on to the

same or near positions. The two girders are finally connected by a sill strip ($\frac{5}{8}$ in. by $\frac{3}{32}$ in.) at B (Fig. 310).

As several girders are required to be made it will pay the builder to build them up flat on a board or bench, blocks and strips of wood being nailed to the surface of the bench, the whole forming a jig, which will ensure all girders being alike in size and form. The base-board of the bridge may be a plank or planks of thin wood ($\frac{5}{16}$ in.) on which the track is laid, the whole being put into place

Fig. 312.—Model Forth Bridge

when completed. This plank is supported by the cross members, and may be rebated $\frac{1}{16}$ in. at the outer sides to fit over the side angles. The girders should be screwed down through the end strips B (Fig. 310) into the abutments and piers.

While this type of bridge is more suited to a No. 0-gauge line, there is nothing against it being employed on a larger model railway. The space such a bridge would occupy is the only thing against it. The piers and abutments would be painted or distempered a stone colour. If the latter

Portland cement could be dusted on to the surface of the parts while it is wet. The girders would look well painted red or a darker grey than the imitation stonework of the abutments.

Bridges for Large Spans.—Fig. 288a shows a lattice girder, G.W.R. style of bridge, made for a 2-in. gauge indoor line. It embraced a comparatively large span, and was a very imposing piece of woodwork. Another example of a bridge made for a similar object on a combined indoor and outdoor $1\frac{3}{4}$-in. gauge line is the model "Forth" type bridge, illustrated in Fig. 312. It was built after the large outdoor model of the same kind, illustrated in the next chapter, and to improve the appearance the bottom chords of the cantilever trusses were curved, and were made of $\frac{5}{8}$-in. by $\frac{3}{16}$-in. ash strips, steamed and bent to the required curvature. The 24-in. posts forming each centre of the cantilever frame were five in number, of 1-in. by 1-in. section, and were inclined inwards towards the top. The distance between centres of the cantilevers was 8 ft. (clear span about 7 ft. 6 in.), and although the centre girder was only $4\frac{3}{4}$ in. deep, made of $\frac{3}{4}$-in. by $\frac{1}{4}$-in. and $\frac{3}{8}$-in. by $\frac{1}{8}$-in. strip wood, the bridge supported a concentrated load of 160 lbs. in the centre.

Bascule Bridges.—The American invention, the "Scherzer" rolling bridge, is a very successful type of lift bridge, which is fast superseding the old swing bridge. Obviously the plan saves a good deal of space, and as the load is moved like a wheel the power involved in lifting the truss clear of the fairway is very small indeed. In addition, a "Scherzer" bridge rolls upward and back, away from the channel that it spans when in the normal position. In real practice the bridges open and close in less than thirty seconds for each operation.

While all these claims do not apply to model work, there is no reason why some of the advantages of the type of bridge should not be appropriated. Model Scherzer bridges may be made with a single or a double span, but the single span is to be preferred. Where the rear wheel-

Fig. 313.—Scherzer Bascule Bridge

end of the truss needs an extra large counter-balance weight the abutment on which the bridge rolls must be designed so as to allow a portion of the counterweight to drop below the level of the rolling surface, as indicated in the diagram.

As in real practice, Scherzer bridges are moved electrically, a gear pinion being arranged on a shaft at the centre of the rolling surfaces, the abutments are designed

with frames on each side to carry toothed racks along which the pinions travel. There is, of course, no real necessity for this in a small model. The bridge may be balanced so that it will stop in any position into which it is put, and may be locked in the closed (i.e. down) position to ensure the safe passage of a train or locomotive. A simple method of preserving the correct position of the bridge on the rolling plane would be to face each wheel surface with a strip of metal, having $\frac{3}{32}$-in. holes drilled in them at a pitch of $\frac{3}{16}$ in., the plane surface being studded with pins projecting, say, $\frac{1}{8}$ in., with well-rounded points.

Fig. 314.—Model Scherzer Bridge (Leeds Model Co.)

This would ensure a true motion, and if the fixed abutment girders are employed a shaft may be fitted to the centre of the rolling portion with projecting ends engaging a slotted piece of metal (angle brass) fitted to the top of the fixed girders.

Where the bascule bridge is employed to span a gap which is used frequently the bridge may be counter-balanced so that it will normally remain in the open position. It may then be arranged to be held down in the running position by suitable sliding bolt locks.

Model girders may be built up out of strip wood, the rolling sections being made out of pieces of $\frac{7}{8}$-in. hardwood

planking, preferably turned to the correct diameter in a lathe. The counterweights can be hollow boxes made of thin wood fixed to the rolling members and filled with sand or lead shot. Small cross ties to wooden bridges are easily modelled by using perforated strips of metal supplied for making bird-cages.

CHAPTER XIII

Outdoor Model Railway Bridges

Large Model Forth Bridge.—It was always the writer's aim in constructing an outdoor line to feature the railway so that some bridges could be introduced. On one railway,

Fig. 315.—Model Forth Bridge for 20-ft. Span

a 9½-in. gauge garden model, the presence of ballast and an underground running stream at a certain spot led him to dig for the ballast, and instead of filling up the hole with rubbish to the previous level, the gap was spanned by the model Forth-type bridge, illustrated in Fig. 315. The total length of the girders was 34 ft., and the whole bridge was

made and erected in a couple of weeks out of some old long timbers and bolts.

The Forth cantilever truss is an exceptionally strong type for a long single span, and also looks well when completed. The cantilever, in effect, has the property of reducing the span over which the ordinary lattice truss has to bridge. To cover a space of 20 ft. with a wooden lattice framework would require rather heavy timber. By using comparatively light planks and posts the cantilever truss can be made to reduce the centre span to the dimension c s,

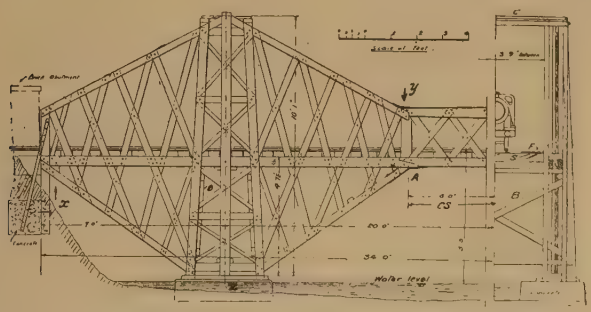


Fig. 316.—Design for Large Model Forth Bridge

about 6 ft. in the case in point. The centre span, of course, exercises a downward load at the points marked *y* in the half elevation view (Fig. 316). Assuming that the cantilever is simply resting on the piers *z*, then there is an upward lift on the abutments *x*. The truss must, therefore, be held down at this point. For the bridge in question, iron straps were used, these being bolted on to the truss end at the top and bedded in a mass of concrete at their lower ends. On these concrete foundations brick abutment piers were built. The whole bridge was sufficiently strong for a concentrated load on the rails of half a ton at any point, or three tons distributed load over the

whole structure. The ruling dimensions for the timbers were 4 in. by 4 in. for the posts, 4 in. by $1\frac{1}{4}$ in. for the main centre horizontals, all of which were in duplicate, and 3 in. by 1 in. for the lattice work and bottom and top duplicated members of the cantilever. The top member of the centre span was 4 in. by 1 in. Five posts were used for the centre of the cantilever, these being cross-braced at B. The tops of the main trusses were cross-connected at C, this providing sufficient head room for any passenger seated in the

Fig. 317.—Mr. A. P. Whatley's Model Three-arch Bridge

train. The rails were carried on cross sleepers S, and a footboard F was arranged on each side of the rails.

This bridge can be made smaller or larger, as desired. If the former, and it is intended for a passenger-carrying train, then the head room under C must be considered. An arched angle-iron could be used here, and the straight cross ties dispensed with altogether.

A Model 3-span Viaduct.—A model bridge of this kind (see Fig. 317) was built many years ago by a pioneer in model-railway work, Mr. A. P. Whatley, and the writer

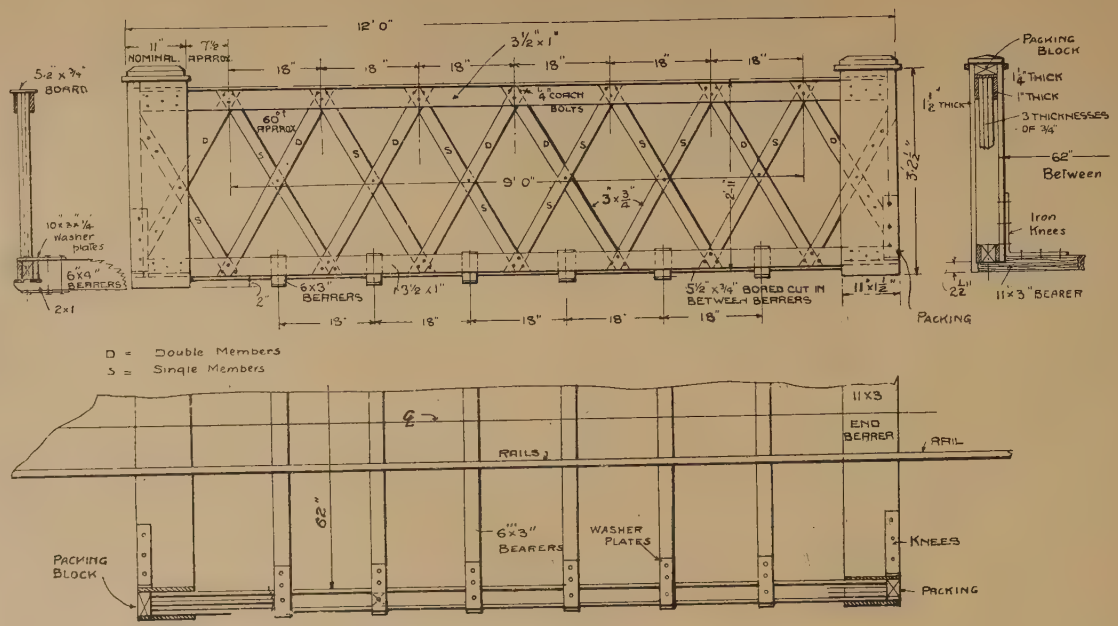


Fig. 318.—Design for Lattice Girder Bridge in Wood

has, therefore, prepared several designs on the lines of Fig. 299 for similar structures in wood which should suit a garden railway of either of the three smaller-standard gauges. As in all wooden models which have to withstand the rigours of a British climate, the pieces of which they are made should be as small as possible, to reduce the tendency to warp. The piers of such a bridge as illustrated in Fig. 317 are, therefore, made of small posts and rails faced with strips of wood, the widest of which would be the 7-in. by $\frac{5}{8}$-in. board used for each side. All work below ground level and inside surfaces should be treated with solignum or other wood preservative. Indeed, the whole bridge could be coated with this preparation, suitable colours for which can be obtained. It must, however, be borne in mind that such preservatives and oil paints do not agree with each other, and surfaces treated with solignum must be quite distinct from those which are to be painted.

It may also pay to drain the floor of the bridge by inserting short pieces of lead tube in the centre of each of the arches.

Lattice Girders.—Fig. 318, although it represents a rather large bridge used for a 15-in. gauge outdoor miniature railway, is typical of a wooden construction which can be adopted for any size of model. Where the dimensions show "feet" they can just as usefully be read as "inches." The 12-ft. bridge which carried a 2-ton engine would, under such circumstances, be a No. 0-gauge model, spanning a gap 1 ft. in width.

In the 15-in. scale girder, the members marked D were double, made of two battens $\frac{3}{4}$-in. by 3-in. section, those lettered S being single battens of the same dimensions. For a small model single strips throughout would suffice. In

the example illustrated the rails were laid directly on the cross bearers, these beams being slung by bolts and iron washer-plates from the lower $3\frac{1}{2}$ in. by 1 in. longitudinals. For securing the component parts of the truss $\frac{1}{4}$-in. diameter coach bolts were employed, nails being used to hold the members together until such time as the bolt holes could be drilled and the bolts inserted. The nails were, of course, left in, and the positions chosen were clear of the bolts.

The top edges of the longitudinals may be capped with a wide board, as shown in Fig. 318, but at the bottom

Fig. 319.—Model Girder Bridge as at Geneva and Margate Miniature Railways

separate strips should be employed to each board. Otherwise the two bottom longitudinals will form a receptacle for rain water.

Fig. 319 is a model viaduct for a 15-in. gauge line built by the author at Geneva. A similar bridge was recently erected for a children's pleasure railway at Margate. The spans were arranged on a 100-ft. radius curve, and have a mean length of 16 ft. With the abutments the viaduct measures 100 ft. long.

CHAPTER XIV

Station Buildings

Buildings in Wood.—In imitating buildings in wood to a small scale care must be taken to avoid clumsiness. As a rule, at the gable end of a roof the end of the slates or tiles overhangs the brickwork or barge-board, as the case may be. Now $\frac{3}{16}$-in. or $\frac{1}{4}$-in. wood would be as thin a material as the average model maker is likely to handle in this connection, but it would look coarse to see it projecting over the face of the brickwork. It is advisable, therefore, to rebate the edge of the roof material, as shown in Fig. 320. Of course, if very thin boarding or metal is used this rebating is not necessary. As sketched, the projecting edges P should not be more than $\frac{1}{16}$ in. thick, the faces Q fitting inside the walls of the building.

The fitting of the ridge board is another item which is often very carelessly done. The gable-end wall should be notched for the ridge, as shown at A (Fig. 320), and should be just a trifle longer than the roof. The fitting of a small moulding to represent the guttering of a roof will be improved by the addition of a deep string course or fascia board, as at S. On the gable end the gutter will be omitted, of course. Fig. 322 shows the addition of a barge-board to a gable end. This item improves the colour scheme of a gable end if the barge-board is picked out in white, or any other light tint. The barge-board should be in two pieces, as at A (Fig. 323), or made up of a section, such as shown at B in the same figure, the idea being to obtain a heavy

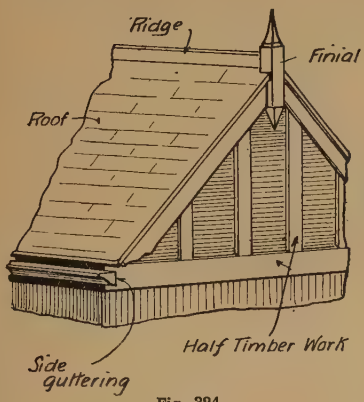


Fig. 324

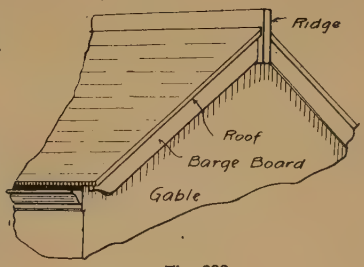
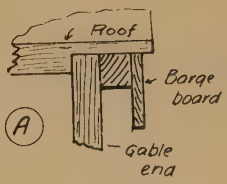


Fig. 322



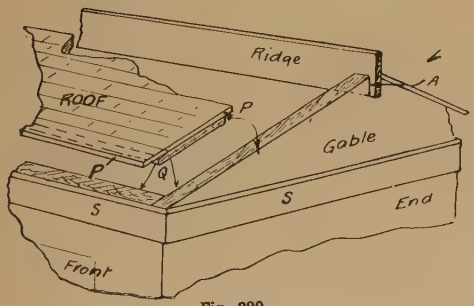


Fig. 320

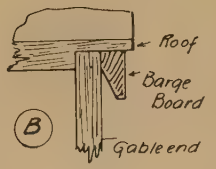


Fig. 323

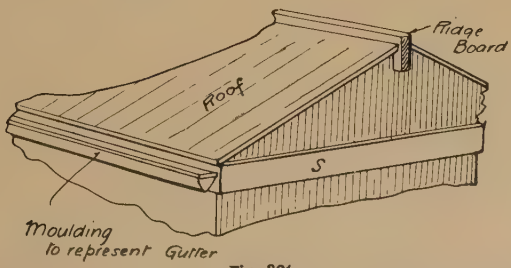


Fig. 321

Figs. 320 to 324.—Roof Treatments of Model Buildings

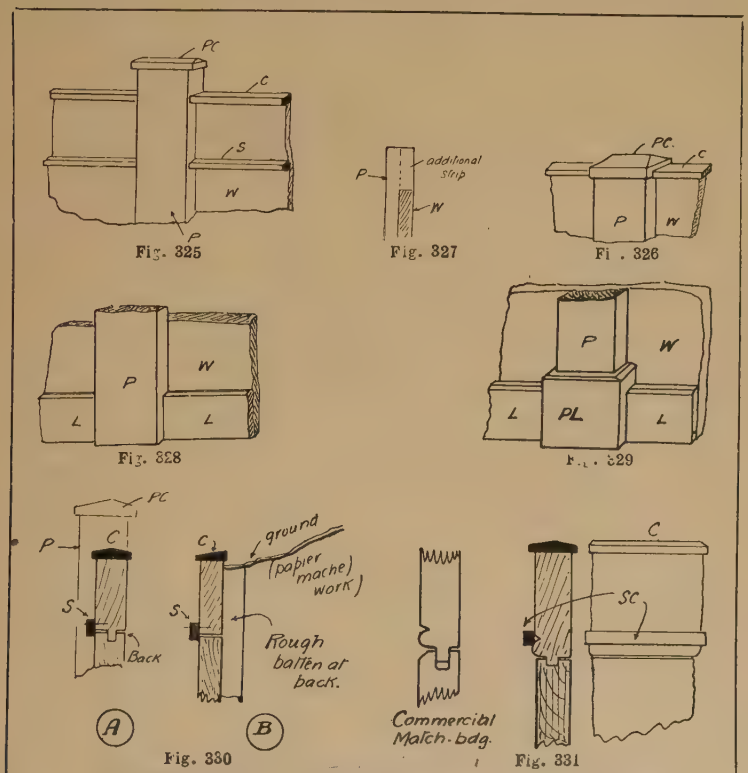
shadow under the board. The ridge should extend beyond the board, or a separate finial may be applied, as illustrated in Fig. 324. This sketch shows the addition of vertical strips to the gable, to represent half-timber work. The strips may be picked out in white on a dark ground or painted in a darker tint on a white ground. For various model railways the author has designed in this style station buildings which proved very attractive when nicely painted in flat colours. Such half-timber work is usually applied to the gables of steeply-pitched roofs. Roofs of the "classic" type with angles below 45° require a horizontal treatment. String courses, as at S (Fig. 321), are, therefore, introduced.

Retaining Walls.—In making walls out of wood a considerable amount of work can be saved, and many troublesome long pieces of small-section wood eliminated, by arranging the piers to definitely break into the horizontal strips, such as used to represent cappings and string courses (see C and S, Fig. 325).

The piers (P) are formed by fixing vertical strips on to the face of wooden walls. These tend to keep the planks from warping, as the grain of the pier strips cross the wall at right-angles. If the piers are arranged to project above the wall, as shown in Fig. 325, then an additional strip, the same thickness as the wall, will be required to render the surface of the back continuous. This may be avoided by making the piers the same height as the wall, as shown in Fig. 326, using a heavier pier capping (PC) in comparison with the wall capping C.

In arranging plinths the same scheme may be applied. The simplest idea is to fit a plinth which is thinner (i.e. projects a lesser amount from the surface of the wall) than the pier, and to omit the plinth (L) at the pier itself. This

is shown in Fig. 328. But if the addition of a plinth to the pier is necessary to the architectural effect of the structure, then cut the pier strip short of the bottom of the wall and insert a thicker and wider block (PL, Fig. 329) in



Figs. 325 to 331.—Retaining Walls and Abutments in Wood

the space provided. It is essential that this block should be higher than the wall plinth L, as shown in Fig. 329.

As a rule, retaining walls require no special finish at the back, but to restrain the plank from warping it may

be necessary to reinforce each of the piers from behind with a rough batten. These strips must, of course, not be seen.

As wide boards are liable to crack walls may be made in two widths. Where, say, $\frac{5}{8}$-in. matchboarding is used, it may be applied as shown in Fig. 331, the string course S being used to "break" the joint. This, in architectural language, means masking the joint by a shadow line. If a beaded-matching is used the bevel of the grooved board may be removed. This will make the joint less clumsy in a small-gauge model.

Fig. 330 illustrates two other methods of dealing with longitudinal joints; at A, a plain grooved and tongued board is shown, and in the other a plain butt joint with rough battens at the back to hold the two parts together (with, of course, the help of any pier strips). In both cases the small strip forming the string course is panel-pinned (and glued) to the upper board only; the bottom plank can then freely move with climatic changes without showing the joint.

Model Platform Shelter.—As a model "halt" station, or for the "off" side of a wayside country station, a platform may be made with a shelter over its centre portion in the manner illustrated in Fig. 332. The dwarf wall or fence at the back of the platform will be stopped at the shelter, to which it will butt, and will be replaced with a higher wall reaching up to the eaves of the roof. The wood forming the side walls will be in one piece with the roof gable, the overhanging portion being supported by wooden columns. The outer columns may be half lapped on to the inside of the gable ends, and the centre one will come under a strip of wood fitted inside the roof, as at A (Fig. 332). Inside the shelter a long seat may be arranged, as shown in the sketch. The drawing is dimensioned for a No. 0-gauge model, but, as usual, a scale is

provided to make the drawing useful for a railway of the next larger gauge.

A Suburban Through-line Station.—A very effective arrangement for a through-line station with a bay road in No. 0 gauge is illustrated in Figs. 333 to 335. The station is supposed to be a level lower than the surroundings, such as would obtain in a town or suburban area, a roadway

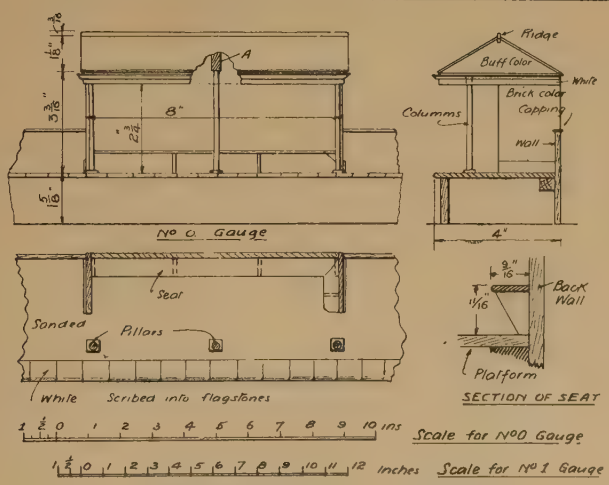


Fig. 332.—Model "Halt" Station

crossing the station at one end. One side of the model, at least, would be flanked by a high retaining wall, which, of course, would lend itself to the application of miniature advertisements. The treatment of the foreground of the overhead roadway, if the station is used in or near the centre of a straight length of line, would, of course, have to be considered with reference to the site, but if there is no other alternative but to cut it off short, then a retaining wall of the stepped pattern might be introduced (see Fig.

335). It is, of course, almost impossible to model the foreground of a model railway with any degree of completeness, and much has to be left to the imagination of the observer.

Alongside the roadway the booking office consists of a square tower-like building, and from this erection the "lean-to" covered way leading to the near-side platform is built. Both platforms have steps leading up to the overhead covered way and booking office. These are solid blocks of wood with their upper surfaces sawn into steps and their sides flanked with dwarf walls made of thin wood.

The model illustrated was built up as far as possible from examples of standard model buildings, and, perhaps, does not represent exactly what would be done in full-size practice. The arrangement of the far-side platform (which is really a small complete countryside station) could be reduced in overall width, if not improved, by making it integral with the retaining wall. This style of things is illustrated in another model station (Fig. 336). Here the retaining wall is fitted with platform, windows, waiting-room, etc., and supports an awning for a portion of its length.

As originally set out in the photograph (Fig. 333) the far-side platform, by having a dwarf wall flanking it, suggests the presence of a siding between it and the retaining wall. Should this be required, and if there is sufficient lateral space for it, the arrangement may be amended to suit. The station would then comprise four roads.

A Country Branch-line Terminus.—Most model-railway holders, after having passed the "circular track with wayside station" stage, aspire to the construction of a large terminus, but very often considerations of space and the

Fig. 333.—Model Suburban Station

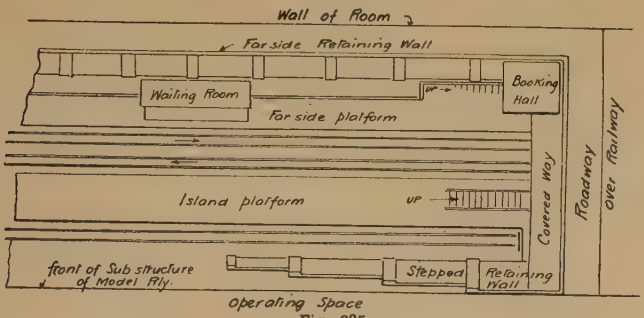


Fig. 335

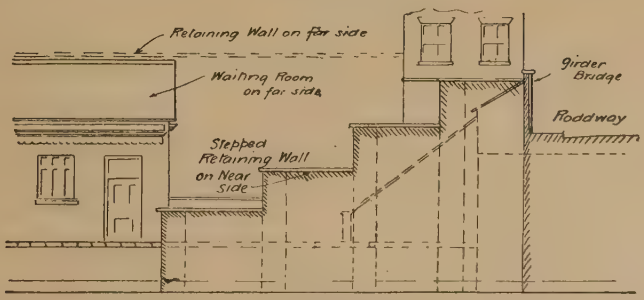


Fig. 334

Figs. 334 and 335.—Elevation and Plan of Model Suburban Station

time involved will cause a much less ambitious scheme to be installed. The country terminal station, such as would be found at the rail-head of a short branch line, therefore suggests itself, and is illustrated in Fig. 337. This example has been prepared with a view to accommodating two passenger roads. The building and concourse can be made entirely separate from the long platforms, these butting up against the former, as indicated in the block plan A (Fig. 337).

Fig. 336.—Station Arranged against a Wall

The station building is quite small (see Figs. 337 to 339). It would be easy to increase its area, and if any such enlargement is desired it may well take the form of an increase of length. Where the front (i.e. the front to the roadway) is visible, the appearance of the station may also be improved by the continuation of the awning around the front, as far as, say, the tower. The "up" or arrival platform could then be made into an island platform and widened to, at least, 100 m/m (4 in.), an umbrella awning being arranged along its centre, on suitable pillars. The ground plan of the station would then be as shown in

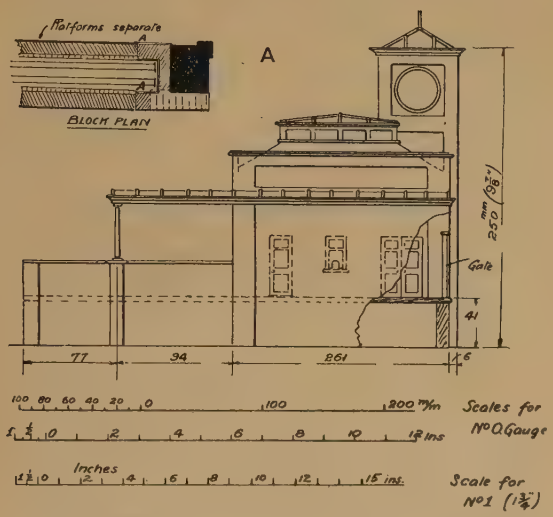


Fig. 337.—A Country Branch-line Terminus

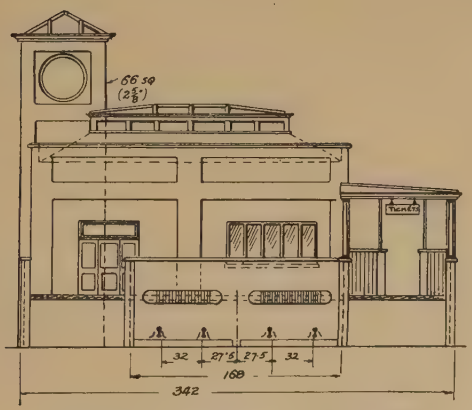


Fig. 338.—Passenger Concourse End

Fig. 344, and would suit a position where the "down" platform is against one of the walls of the room, as indicated.

The lantern may be smaller—nearly square—the rest of the roof being flat, with strips glued on at intervals to represent the rolls of a lead covering. Needless to say, the roof would be painted a dark blue-grey. As designed, the

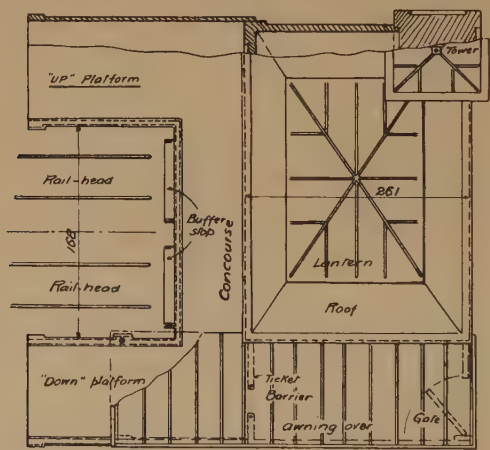


Fig. 339.—Plan of Buildings

roof would be treated something after the style shown in Fig. 340. The part of the roof around the lantern could be made from a piece of pine plank, or from four battens, fixed to a thinner piece of board and mitred at the corners. If it is desired to light the interior of the station the sides of the lantern may be made of four strips of ground glass, bristol board pierced to represent the mullions and window openings being stuck on to the sides of the glass, the latter fitting in rebates formed in the two wooden roofs, as detailed in Fig. 341. Rebate planes are not often to be found

in a model-maker's kit-bag, and it is, therefore, suggested that rebates can be made by planting one narrow strip on another which is wider. Indeed, a plentiful supply of small wooden strips, planed quite square and smooth, is mainly what the builder requires to embellish his models.

The roof of this model will, perhaps, be considered to

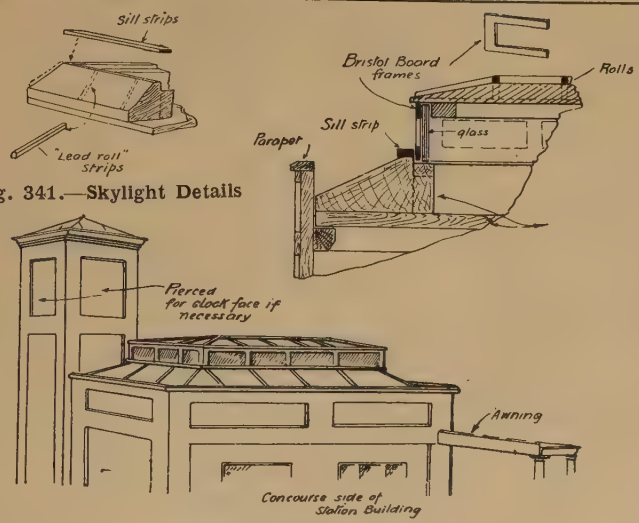


Fig. 341.—Skylight Details

Fig. 340.—Roof Treatment

involve a large amount of work. This may be so, but it will be found well worth the trouble. The observer sees mainly roofs in viewing a model railway, and, therefore, readers are recommended to give as much thought and care to the construction of the roofs of their model buildings as they can spare. The awning may be made solid and painted either to represent a lead or a glass roof, or it may be made like a picture frame and hold one sheet of ground

glass. The ribs (sash bars) which would hold the sheets of glass in full-size construction may be glued on to top surface. Figs. 342 and 343 show the two constructions.

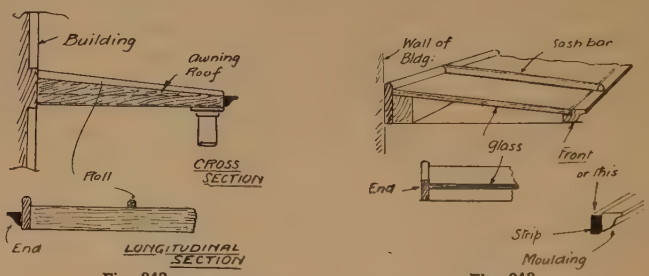


Fig. 342 Fig. 343

Figs. 342 and 343.—Awning Details

The tower is made out of a $2\frac{3}{4}$-in. square block of wood of suitable length, the panelling being obtained by gluing and pinning on strips to finish $\frac{1}{16}$ in. in thickness, these being cleaned off on a sand-paper surfacing block when the glue is set. The construction of the roof cap is obvious.

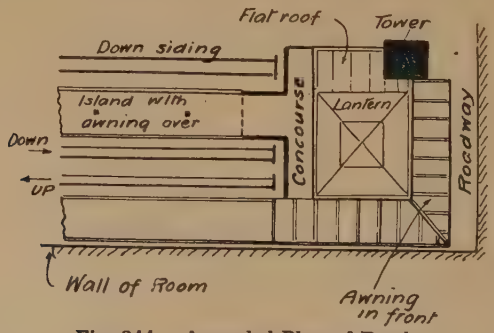


Fig. 344.—Amended Plan of Roads

Model Goods Sheds for Country Stations. — Model goods sheds take two forms: (1) those in which the trucks run right into (or through) the shed, and (2) depots which

are simply brick warehouses and have openings in the side with sliding doors through which goods can be loaded into trucks on an adjacent line of rails. An awning is usually provided over rails at the opening.

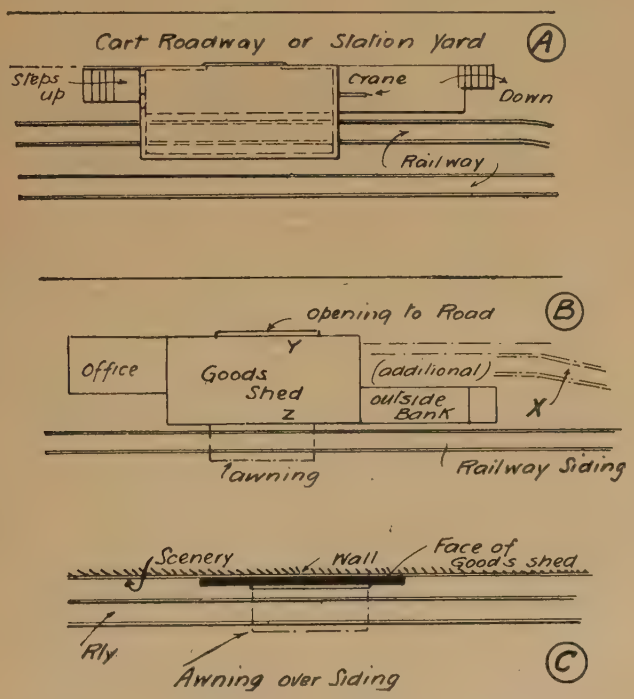


Fig. 345.—Methods of Planning a Goods Shed

The first type is better than the second, as the total space occupied is less, as will be seen by the sketches A and B (Fig. 345). Of course, the type of shed B can, where the line of rails must be laid as closely as possible to the wall of the room, be made an incomplete building. A half

building, like the half model of ships one often sees in glass cases, or only the front wall of the structure, may be made, this latter being applied to the surface of the painted scenery behind the model railway, as shown at C.

Goods Shed with Through Road.—A simple model of the type of shed sketched at A (Fig. 346) is illustrated. It is designed to take up a space less than two roads wide, but if the exigencies of the site render necessary a further reduction laterally, this can be obtained by altering the pitch of the roof slightly. An alternative method is included showing a short outside loading platform or "bank." This may be adopted where the length of the siding is not limited to that of the building, and the whole appearance of the model thereby considerably improved. This extra part may be made as an entirely separate piece and fixed to the substructure of the line alongside the main building on completion.

In arranging a model goods shed in a realistic manner, it must not be forgotten that the side of the shed opposite to that next the railway should be approachable by horse cart, and that a suitable space should be provided for this purpose. This may, of course, be much less than the scale equivalent.

The total height of the building will depend slightly on the permanent way used, but if the clearance above rails is more than 96 m/m ($3\frac{13}{16}$ in.) all wagons will pass through without trouble. Engines, as a rule, are not allowed inside goods sheds. As the clerk's office would be on the platform ("bank") level, a set of model stone and brickwork steps is provided. These may be cut out of one piece of wood and a dwarf wall D (Fig. 346) applied to one side, as shown. The door is arranged in the end of the building opposite these steps. A doorway in this position is easy to make,

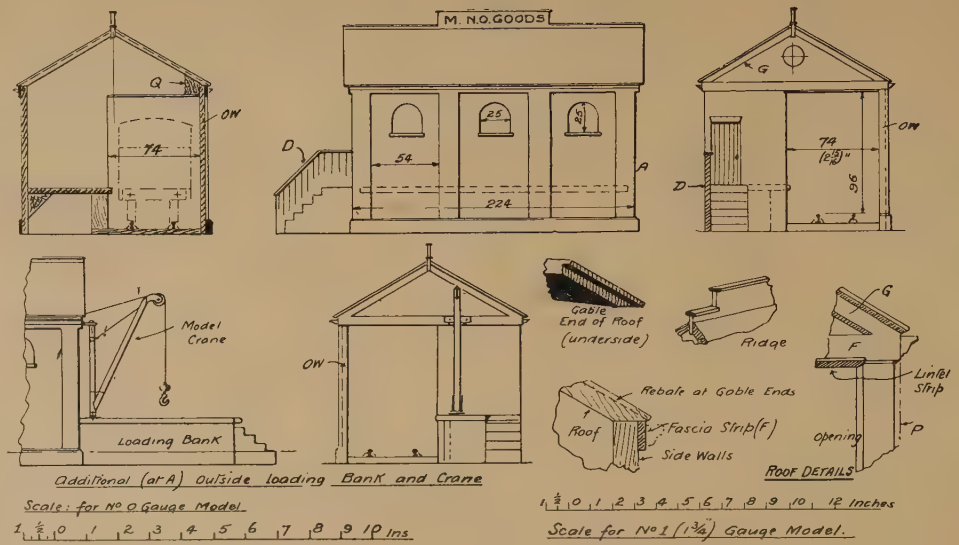


Fig. 346.—Model "Run-through" Goods Shed (Type A)

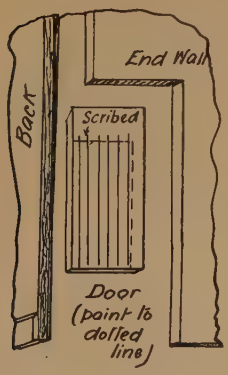


Fig. 347.—Detail of Door

and need not open. One edge of the end wall is notched out with the saw, and as it abuts the back wall the reveals of the doorway are formed automatically. To fill the hole up, a piece of wood with lines scribed down it and the *visible* part of the face painted buff, or any other colour, to contrast with the walls, is glued and pinned in place, as shown in Fig. 347.

Another method of making the door is shown in the next illustration. Here the end wall is of the full width of the model building, and notching it for a doorway will necessitate filling the space up again with a door-post, as at D P (Fig. 348). In both cases the head or lintel strip and the threshold will require to be made and fitted. The latter may be a strip fixed to the adjacent face of the step block, as indicated at T.

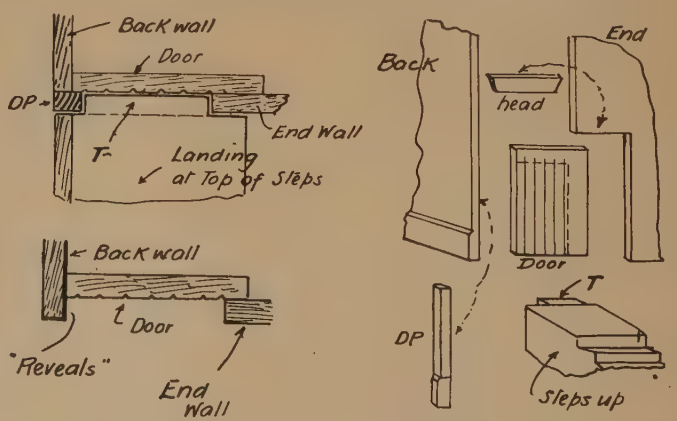


Fig. 348.—Further Details of Door

The outer wall of the shed (see Fig. 346, O W) is simply a comparatively thin plank of wood, and to stiffen this, as well as to prevent warping, it is essential that this wall should be panelled out by pilasters made of strips of wood running vertically, thus crossing the grain of the wood forming the wall. The wall is also pierced with window openings, which may, or may not, be glazed. If the latter, the construction adopted for the model-engine sheds (see Chapter XV) described in these pages may be adopted. The back need not be panelled or otherwise embellished unless it is visible when the shed is fixed in its final position on the model railway. The outer wall (O W) has added strength given to its fixing at the top by a strip of wood which fits between the ends and is secured to the roof. The gable end of the shed has the fascia strip F carried across it from side to side, and a sort of a barge-board G (Fig. 346) is fitted next to the roof. Both these, if picked out in suitable colours, will help the appearance of the finished model. To strengthen the model a thick roof is suggested. This is rebated at the gable ends, and at the eaves is planed flat in a horizontal plane to sit on the top of the side walls. This, the capping and shape of the ridge (the latter may be painted with the chosen initials of the

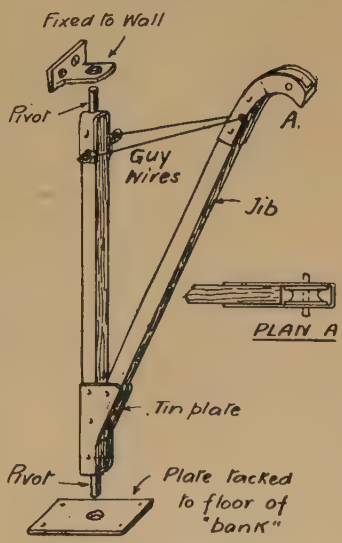


Fig. 349.—Model Crane

railway and the purpose of the shed) are all detailed in the perspective sketches included with the general-arrangement design.

The model crane need not "work" in the fullest sense of the term. It may be of a spectacular character only. It may be built up of some $\frac{3}{16}$-in. or $\frac{1}{4}$-in. strip wood and small pieces of metal sheet with a suitable pulley. Fig. 349

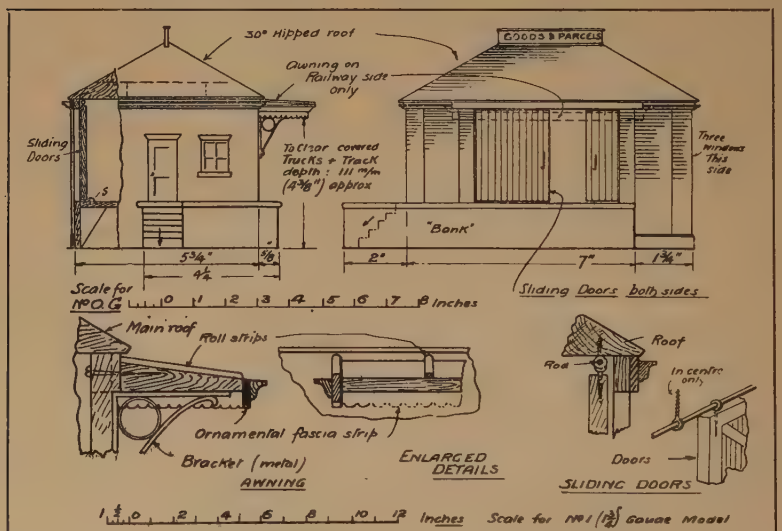


Fig. 350.—Model Goods Shed (Type B)

shows a method of construction which may be adopted. Ordinary household pins and seccotine may be employed in fixing the parts together. An opening to the cart road side of the shed may be provided if the position of the model warrants the work involved in making the sliding doors which would be employed to close this opening.

The design (Fig. 350) is representative of the second class of goods station (see sketch B, Fig. 345), except that

Fig. 351.—Model Passenger Station with Platform Awning

the extra office building alongside the shed is omitted. In the shed (Fig. 350) a hipped roof is introduced, and may be simply made by building up layers of wood into a block big enough to plane to the required shape. The awning is made separately and fixed on to the main structure by

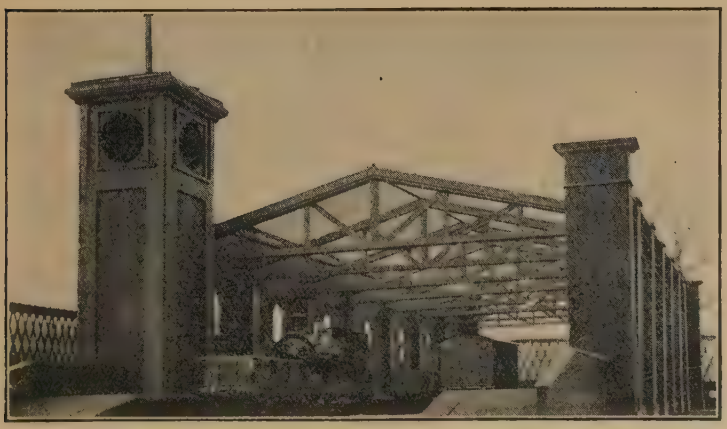


Fig. 352.—No. 0-gauge Covered Station as at Worcester

Fig. 354

Fig. 353

Figs. 353 and 354.—Views of 2-in. Gauge Terminus Station

screws from the inside before the main roof is fastened down. Brackets may be used in supporting the awning, and are fittings which can be obtained from model dealers. If found to be too flimsy to do the whole work of holding up the awning, they may be applied as ornaments only, the fixing already suggested being employed as the main one.

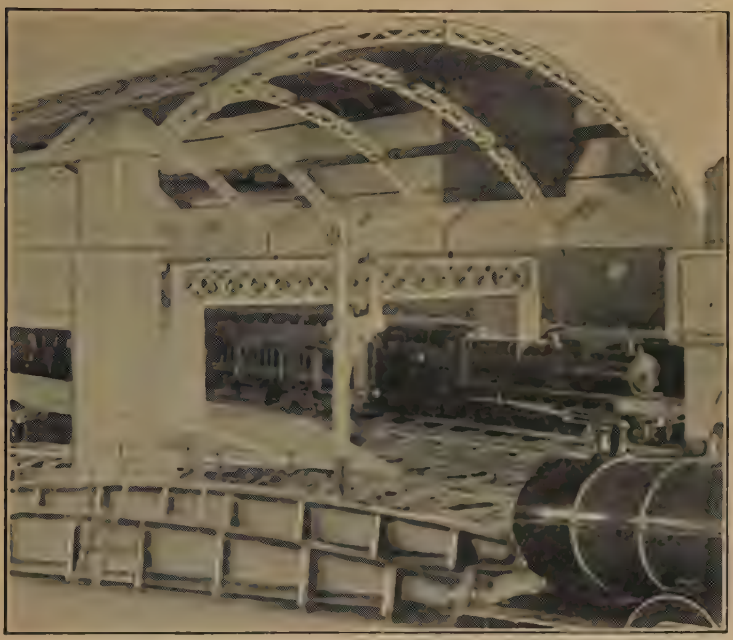


Fig. 355. "Close-up" of 2-in. Gauge Terminus Station

The sliding doors may be arranged to work in wooden runners at the top and bottom, but the best scheme would be to procure some very small screw eyes and to hang the doors from a steel rod (e.g. a knitting-needle) fixed in holes in the ends of the building and by a single eye driven into the roof in the centre. This middle support acts as a stop

for the doors, and if arranged in this way the bottom "side-control" runner strips need not cross the doorway opening.

Large Model Passenger Stations.—Designs for model-railway stations are legion. In rebuilding many of their old stations our railway companies have discarded the entirely covered station for a type in which only the platforms are roofed, what are termed "umbrella" roofs being erected on stanchions from the platform. The station buildings have their own roofs, as in Fig. 351, and awnings to match the "umbrellas" of island platforms surrounding such buildings where necessary.

The photograph Fig. 352 is an example of No. 0-gauge model of a covered station. The glazing has been removed. Old negative glasses are supported by trusses built up like lattice girders out of strip wood. These trusses rest in "piers" formed on the wooden sides of the building. The ends of the walls are finished by suitable towers, one being larger than the other to accommodate a clock—actually a watch. Trusses for the all-over type of roof may be built up out of angle brass after the style of the lattice girder of the bridge (Fig. 305), a jig being fitted up on the bench to ensure the several girders being of the same size. The roof of the large model 2-in. gauge terminus station was constructed out of small unit castings in aluminium. Bolted between each of the units is a longitudinal or "purlin" strip of flat metal. The photographs, Figs. 353, 354 and 355, show a very fine model station for a 2-in. gauge railway, built by Mr. E. H. Foster, of Pangbourne, Berks.

CHAPTER XV

Locomotive Sheds, Signal-boxes, etc.

AMONG the many other buildings, huts and sheds that may be constructed to adorn a model railway, the locomotive shed and signal cabin are the most important. Others may include cattle pens, coal offices, and builder's-material

Fig. 356.—Model Loco Depot with Gable-ended Engine House

stores at stations, and field advertisement signs, fogmen's and platelayers' huts along the line, while a considerable interest can be added to a model railway by realistic arrangements of crossing gates, fencing, telegraph poles and gradient posts.

Fig. 356 is an excellent example of buildings at a model locomotive depot. The engine is shown outside its shed being filled with water and oiled up. The water tower is a model of the G.W.R. example at Henley, and is of the

square pattern with model "brickwork" support. The inside of this portion of the model tower is arranged to accommodate the necessary stores of oil and spirit fuel.

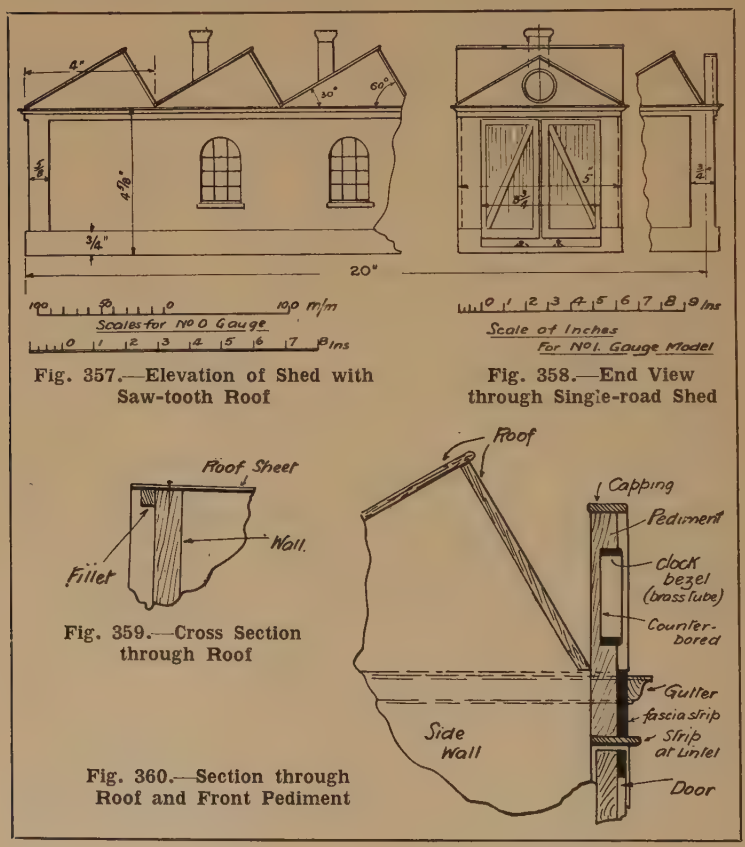


Fig. 357.—Elevation of Shed with Saw-tooth Roof

Fig. 358.—End View through Single-road Shed

Fig. 359.—Cross Section through Roof

Fig. 360.—Section through Roof and Front Pediment

Locomotive Shed with Saw-tooth Roof.—The so-called saw-tooth roof is very suitable for either long or wide engine sheds. In case the latter is necessary, e.g. where four engine roads may have to be accommodated, the single-

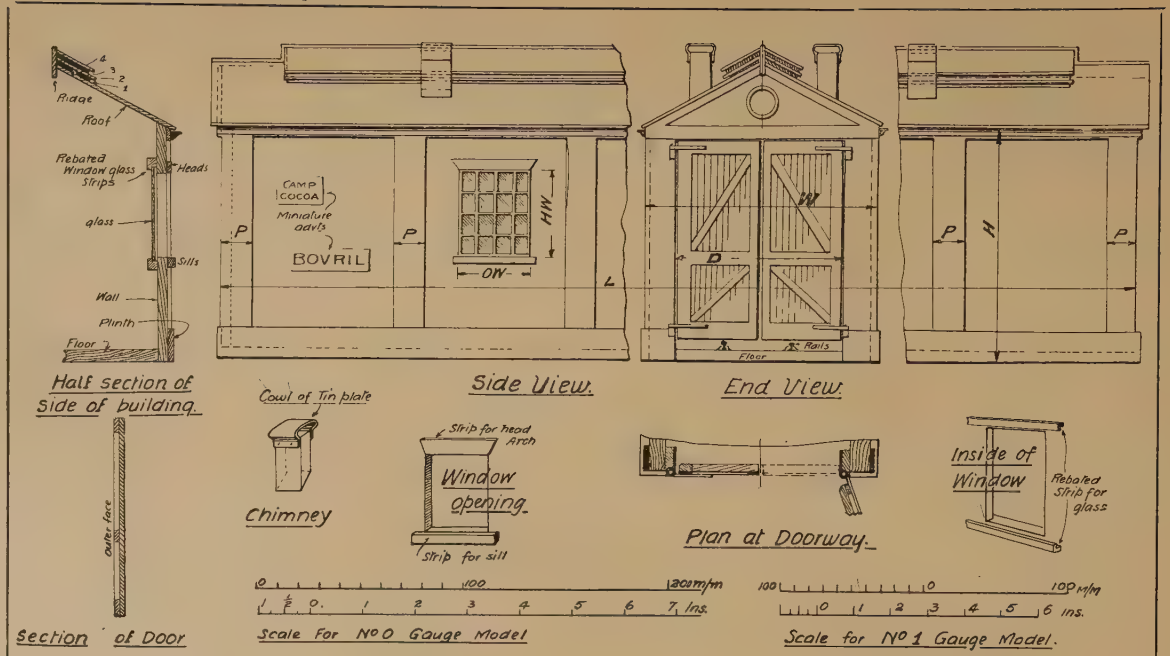


Fig. 361.—Design for a Gable-ended Locomotive Shed

pitch roof involves fairly large boards, whereas the transverse saw-tooth form may be made up of relatively small strips. Fig. 357 gives the leading proportions of a shed for one engine. By extending the width of the shed in multiples of the dimensions given in Fig. 358, and altering the pediment, a shed may be built to accommodate four tender engines.

In each case the roof material must be of thin wood, $\frac{3}{32}$ in. at most, and if any difficulty arises in this respect in the No. 0-gauge model, there is no reason why sheet zinc should not be employed. The appearance at the side walls would, where metal is used, be improved by the planting of a fillet of $\frac{1}{8}$-in. by $\frac{1}{16}$-in. section along the edge of the wall, as shown in Fig. 359. In both cases the end wall over the doorway is ornamented by a suitable parapet and pediment (see Fig. 360). One row of chimneys should be arranged over each line of railway.

The side walls in a model of this kind are usually made in one piece from the floor to the ridge of the "saw-teeth," the shape of the latter being accurately cut out to markings preparatory to building up. Both sides should be dealt with at one operation to ensure accuracy.

As the four-road locomotive shed is not likely to be constructed with a floor, stout battens should be fitted temporarily, between the walls at the open bottom. When fitted into position these may be removed and the walls fixed down to the base-board of the railway.

A Gable-end Engine House.—Fig. 356 illustrates another form of engine-house which has greater pretensions to architectural symmetry. The roof is a continuous one, and is surmounted by an imitation of a louvred clerestory. The latter is often continued right to the end of the roof, but the arrangement shown in the drawings is to be pre-

ferred, in a model at least. It is not easy to make the louvred portion exactly to scale in wood, and any coarseness is masked if it is stopped a short distance from the gable end.

As illustrated, a floor is shown over the whole area. This is, perhaps, the best method of constructing a small locomotive shed, especially if both ends are fitted with doors. Where such a floor is a part of the structure, the rails must be laid without sleepers before the floor board is finally fixed to the sides. The other alternative is to omit the floor and temporarily to fix from side to side a few battens to hold the walls together—as mentioned in a previous paragraph.

The side walls form the main parts of the structure, and as they are, in the smallest model, rather expansive surfaces, some relief can be obtained by arranging pilasters (P), plinth and fascia strips on the outsides, as indicated, with windows in the panels so formed.

The following table shows the leading dimensions in inches and millimetres for single engine sheds in both the smaller-standard gauges:

Ref. Letter.	*Gauge No.* 0 (1¼ *in.*)	*Gauge No.* 1 (1¾ *in.*)
W =	114 m/m (4½ in.)	140 m/m (5½ in.)
D =	82 m/m (3¼ in.)	110 m/m (4⅜ in.)
H =	114 m/m (4½ in.)	165 m/m (6½ in.)
L =	482 m/m (2 ft. 3 in.)	680 m/m (1 ft. 7 in.)
P =	16 m/m (⅝ in.)	25 m/m (1 in.)
OW =	35 m/m (1⅜ in.)	50 m/m (2 in.)
HW =	42 m/m (1⅝ in.)	60 m/m (2⅜ in.)

Detail dimensions can be obtained by using the scales on the illustrations. The length (L) is, of course, a variable quantity, but as dimensioned an average tender-locomotive

can be accommodated. The window openings are pierced in the sides, and are ornamented on the outer faces with strips representing the head arches and sills. A pair of continuous rebated strips may be glued and pinned on to the inside to take the window glasses. These may be made out of cleaned-off photo negatives, the window bars being drawn on with a ruling pen in indian ink or paint. The folding doors (Fig. 361) must be hung clear of the rails at the bottom. These are made by first cutting and planing up rectangles of thin wood and scribing the vertical boarding lines on the outer surface. Strips are then glued on for the stiles, rails and braces, and when set the surface of these members are cleaned up with glass-paper, or by rubbing the doors on a sheet of glass-paper tacked down to a perfectly level surface.

The hinges may be made of brass strip. These are more realistic than the commercial cabinet hinges. The chimneys are rectangular blocks of wood, painted black, with tinplate or zinc-sheet cowls fitted, as illustrated in detail. The circular opening in the gable may either be drilled through or only counterbored half-way. In the latter case it may contain a paper clock dial, and whichever scheme is adopted, a neat brass bezel may be fashioned from a slice off a tube of this material.

The louvres (see Fig. 361) are made up of four strips of thin ($\frac{1}{16}$-in. or $\frac{3}{32}$-in.) wood of the correct overall size laid one on top of the other, it being noted that the first and third strips, counting from the lower one, are $\frac{1}{8}$ in. narrower and $\frac{1}{4}$ in. shorter than the second and the top strips. The ridge board is stepped up at the louvred portion.

Line-side Accessories —Among the many buildings and features of a railway that may be modelled with effect

are: field signs, platelayers' cabins and fog-men's huts. Examples of the first two are illustrated in Figs. 362 and 363. In designing these accessories some license may be

Fig. 362.—Field Advertising Sign Fig. 363.—Platelayers' Hut

Fig. 364.—Model Platform, Buildings, Fences, Crossing Gates and Over-bridge

allowed. The usual fault, however, is that they are made too large. They should be modelled with respect to the scale height of a man, i.e. 42 m/m for a No. 0 ($1\frac{1}{4}$-in.) gauge model and 60 m/m in No. 1 ($1\frac{3}{4}$-in.) gauge.

Platform Over-bridges.—Fig. 364 is an interesting pic-

ture of a model station, which includes in addition to the two platforms and waiting-room, level-crossing gates and a foot-passengers' over-bridge. The latter is made out of two light lattice girders, which are supported on masonry steps. This is one of the simplest methods of constructing an over-bridge, as the steps on each side are made out of blocks of wood serrated to form the stairs, with side walls of thin wood planted on to them. In the design illustrated by Fig.

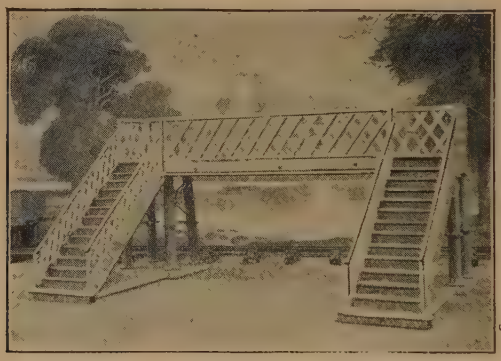


Fig. 365.—Model Platform Over-bridge, with Wallpaper Frieze Scenery

366 the bridge itself is curved at each end. This necessitates some stairs at the curved portions, but reduces the number of steps required at the supports for the girder. The bridge would be made of metal angles or "Tees," and the lattice bracing could be $\frac{1}{8}$-in. mesh tinned-iron screen (which is a commercial commodity), soldered on to the metal frame. Possibly two $\frac{1}{4}$-in. by $\frac{1}{4}$-in. brass angles placed together to form a "Tee"-section with the screen in between would be the best and neatest construction. Brass strips could be soldered across the two lattice frames at each end for the stairs. The supports may be made as suggested in the last paragraph.

Crossing Gates. — These are made from strip wood and hung on metal strap or wire hinges from stout posts fixed

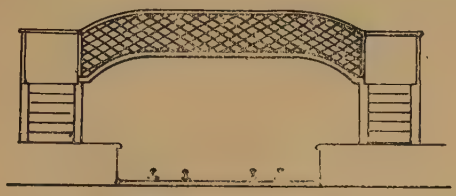


Fig. 366.—Curved Girder Platform Over-bridge

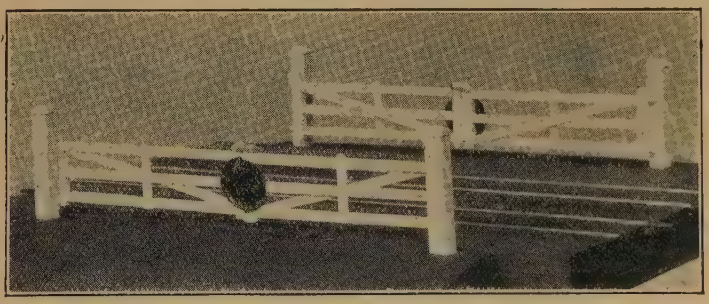


Fig. 367.—A Simple Set of Crossing Gates (Bassett Lowke, Ltd.)

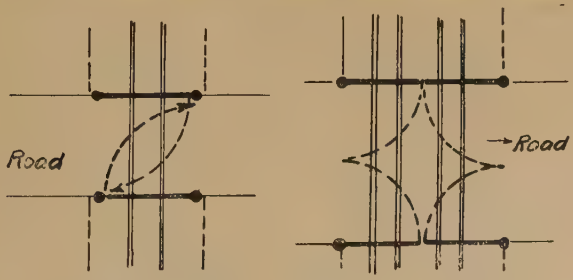


Fig. 368.—Methods of Arranging Crossing Gates

to the base-board. The gates are at least the scale equivalent of 5 ft. high (50 m/m in No. 1 and 36 m/m in No. 0 gauge). At the crossings the spaces between the rails

Fig. 370.—Station Seat and Time-table Board

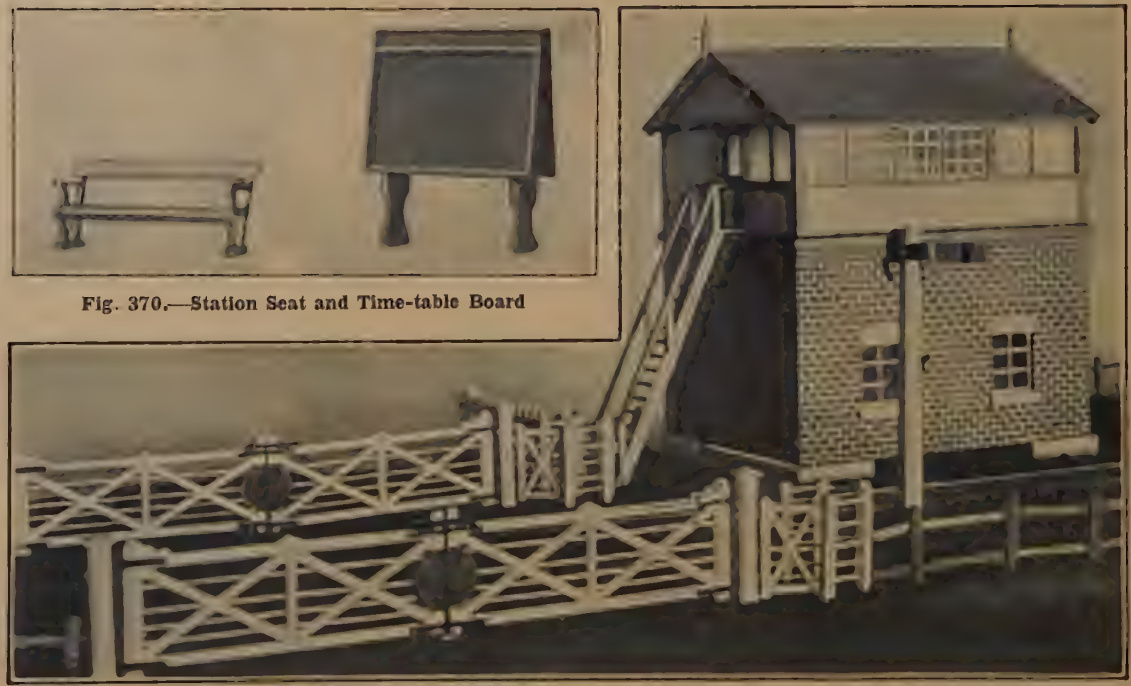


Fig. 369. A Complete Level-crossing with Adjacent Signal Cabin

should be made up to rail level with sleepers. Fig. 369 shows wicket gates for foot-passengers at the side of the main gate. A simpler set of gates is illustrated in Fig. 367.

Fig. 371.—Merchants' Depôts and Coal Offices

As a general rule, on full-size railways, four gates would be used for double-line tracks, and two gates only for spanning single-line tracks, as indicated in Fig. 368.

Fig. 372.—View of Model Station, showing Fences

Platform Furniture.—Platform seats can be made of wire and tinplate bent and soldered together and suitably painted, Fig. 370 exemplifying a seat made up of cast-brass

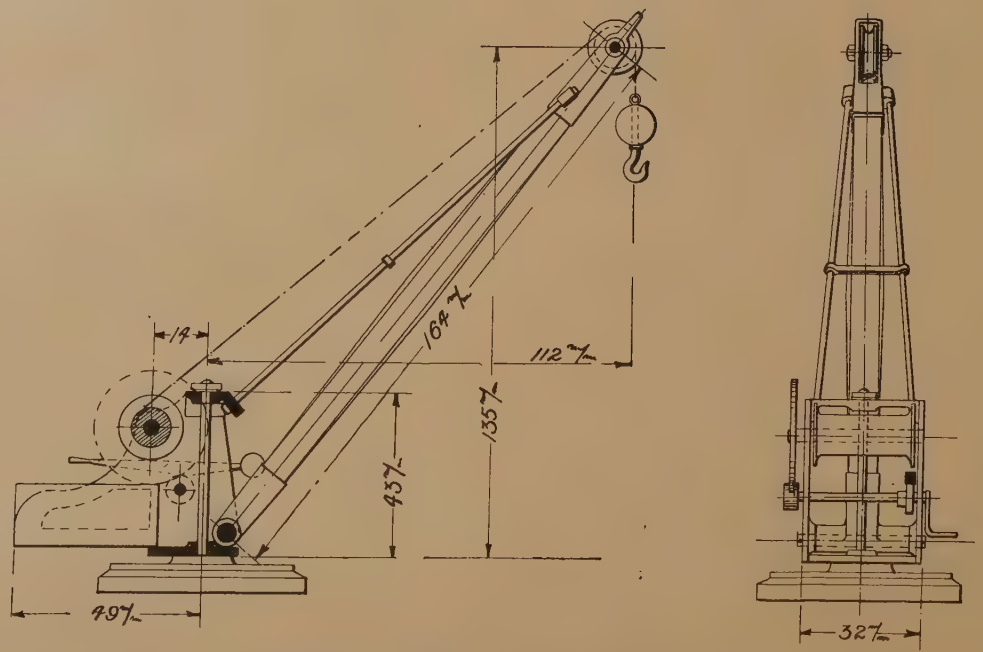


Fig. 373.—No. 0-gauge Jib Crane for Goods Yard

end-frames. Time-table boards, illustrated in the same figure, may be made up in wood, the actual time-tables stuck on them being photograph reproductions or actual specimens cut out of a railway time-table. Quite recently some very realistic die-cast models of weighing and auto-

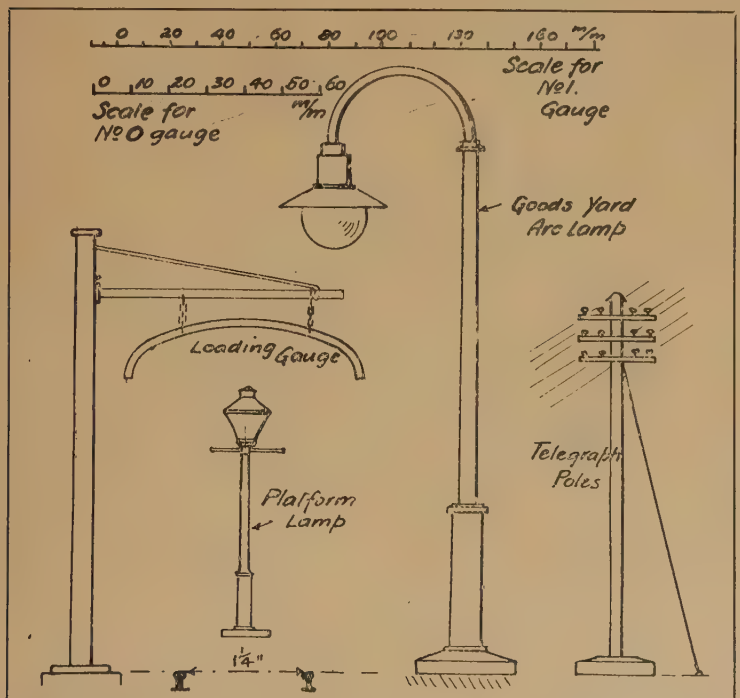


Fig. 374.—Model Lamps, Loading Gauge, and Telegraph Poles

matic sweetmeat machines have been produced. These, with the excellent models of railway station porters, inspectors and passengers, to say nothing of the barrows and luggage, impart an appearance of real life to any well-made model station (see Fig. 372).

Station Yards.—These may be improved by the addition of coal merchants' and builders' offices and stores. Typical models are illustrated in Fig. 371. A jib crane is another interesting model to make, and to this end a design (Fig. 373) is included.

Fences.—Model fencing may be made in a variety of methods. The simplest construction is to cut posts out of squarewood (about 9-in. or 12-in. scale section), and drill them for copper or iron wire. The posts may be pointed at

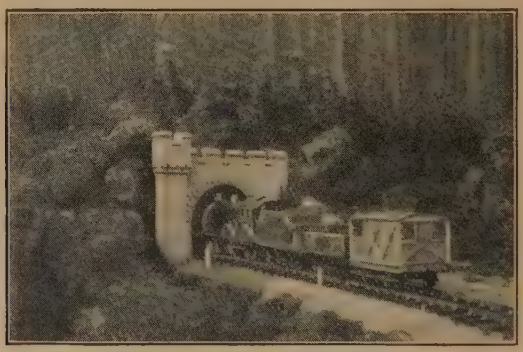


Fig. 375.—Tunnel Entrance on Mr. A. P. Whatley's Outdoor Line

the bottom and driven into holes bored in the baseboard of the railway. Fig. 372 shows a fencing made in this way. Strip metal posts (birdcage strip which is already punched with holes for the wire) may also be employed for fencing.

Lamps, etc —Drawings for model lamps, telegraph poles, loading gauges, are included in the composite illustration, Fig. 374.

Tunnel Mouths.—Among the other scenic accessories tunnel entrances are popular. For indoor models these may be made in wood and painted and sanded to represent stone. Out of doors concrete may be employed, the

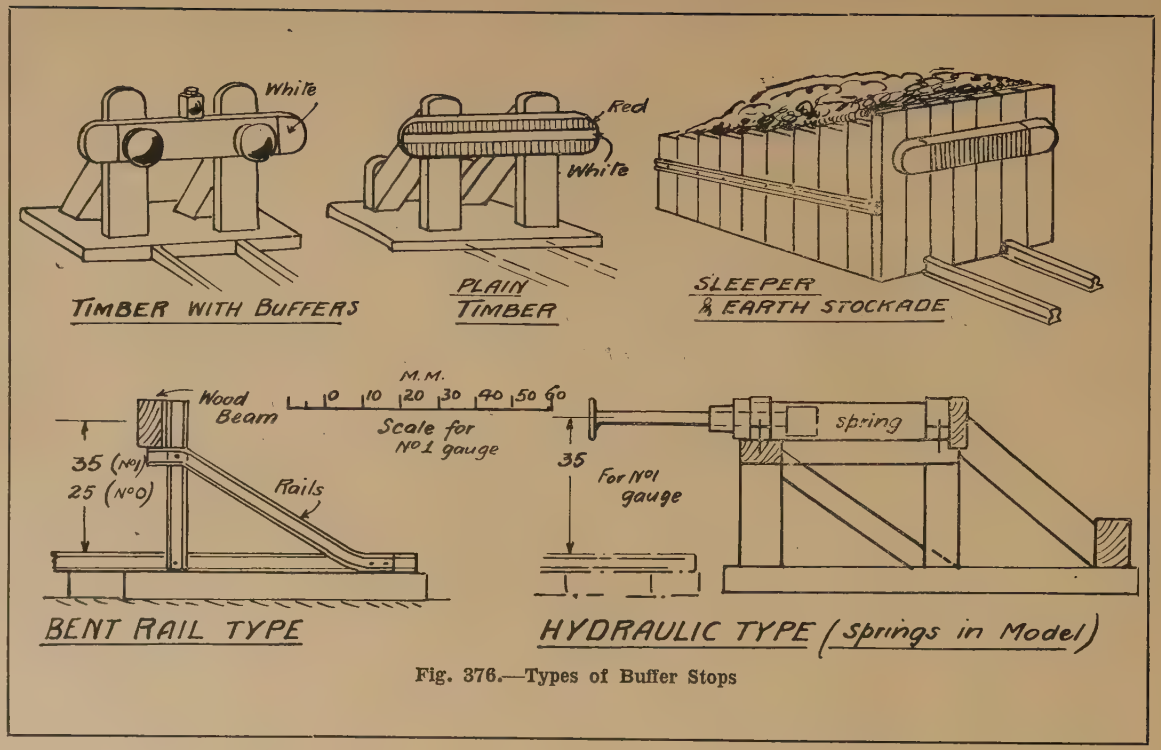


Fig. 376.—Types of Buffer Stops

entrances being cast in previously prepared moulds made of wood. Iron castings also withstand the effects of weather if occasionally painted. For an out-of-door railway earthenware drain-pipes are to be recommended for tunnels driven under ground or through garden rockeries. The track should be laid on stout battens, so that it can be made complete on the bench and then pushed into the tunnel. A long, curved tunnel should be arranged with one or more man-holes so that the joints of sections of track can be fitted together, and so that a derailed train may be extricated with less difficulty, should such an accident occur.

Buffer Stops.—The end of a model railway naturally requires buffer stops. Of these there are many prototypes to choose from, some of which are shown in the final illustration to the railway section of this volume.

CHAPTER XVI

Model Railway Rolling Stock

TYPES of railway vehicles, both in the coaching and wagon stock, are legion, and it would be a hopeless task to illustrate even a tithe of the carriages and trucks to be seen running on a British main line during a single afternoon's visit to any large station or railway depôt. The amalgamation of our great trunk lines will also tend to alter the

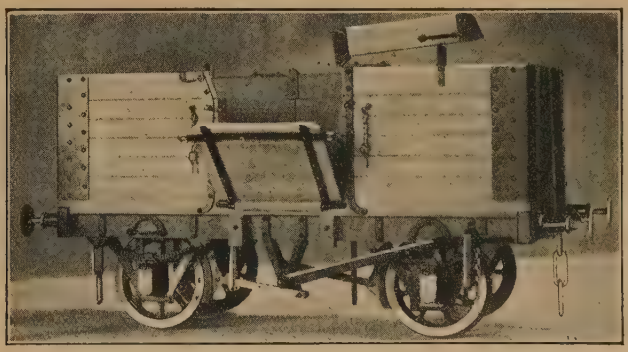


Fig. 377.—Model 3¼-in. Gauge Standard Wagon

individual characteristics of the vehicles of the old companies, and has already simplified the system of lettering.

Wagon Stock.—In this country quite a large proportion of the smaller wagons are owned by private firms. These, however, are built to standard specifications laid down by the railway companies, and are therefore more or less alike. One of the official drawings for a 10-ton standard wagon with high sides is illustrated in Fig. 378,

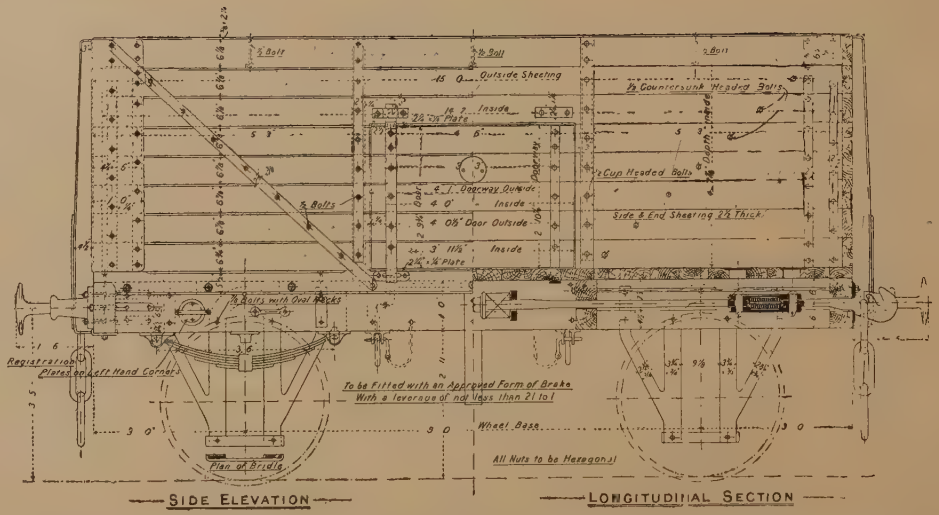


Fig. 378.—Official Design for Standard 10-ton Private Owner's High-sided Open Wagon

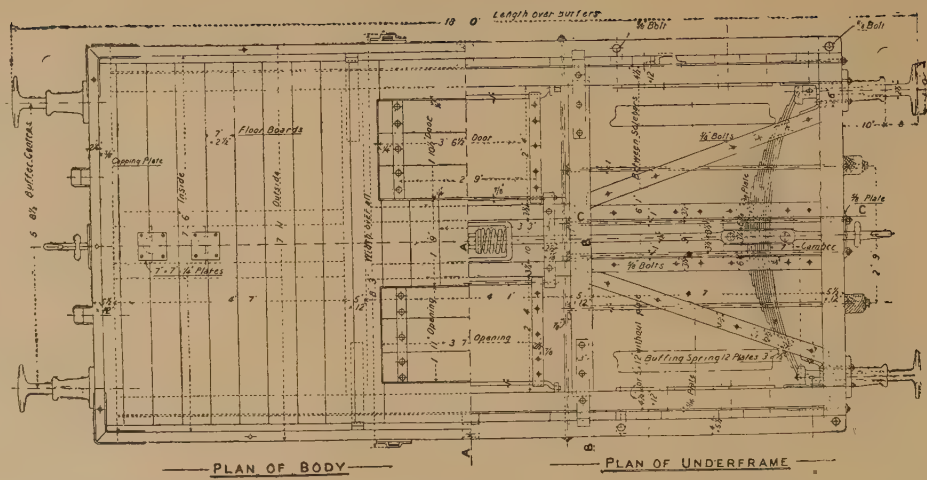


Fig. 378a.—Plan of Body and Underframe of Open Wagon shown by Fig. 378

and Fig. 377 shows an excellent scale model, made for a 3¼-in. gauge track, from die-cast metal parts supplied by Messrs. Bassett Lowke, Limited. It is, of course, not usual where the model-railway builder requires dozens of wagons to render his line complete for him to add such a wealth of detail. For smaller gauge railways wagons are therefore made on a simpler construction, although die castings are made by the L.M.C. firm for such embellishments as strappings, brakes, corner plates, in addition to the ordinary

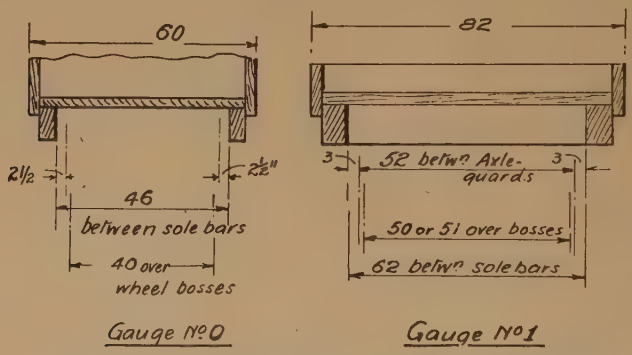


Fig. 379.—Standard Wagon Body and Frame Dimensions

axle guards, buffers, draw-hooks and wheels, which are absolutely necessary to the running of a model wagon.

Fig. 379 shows the standard body dimensions adopted by the writer for No. 0- and 1-gauge wagons. These arrangements suit the standard die-cast axle guards illustrated in Fig. 380. These are sold by all dealers in two gauges and in two styles, the short "**W**" type for wagons of all kinds and the long spring type marked c in the drawing for four- and six-wheeled vehicles, such as horse-boxes, etc., which work on passenger trains, and for four- and six-wheeled passenger coaches.

These axle guards are screwed on to the inside of the

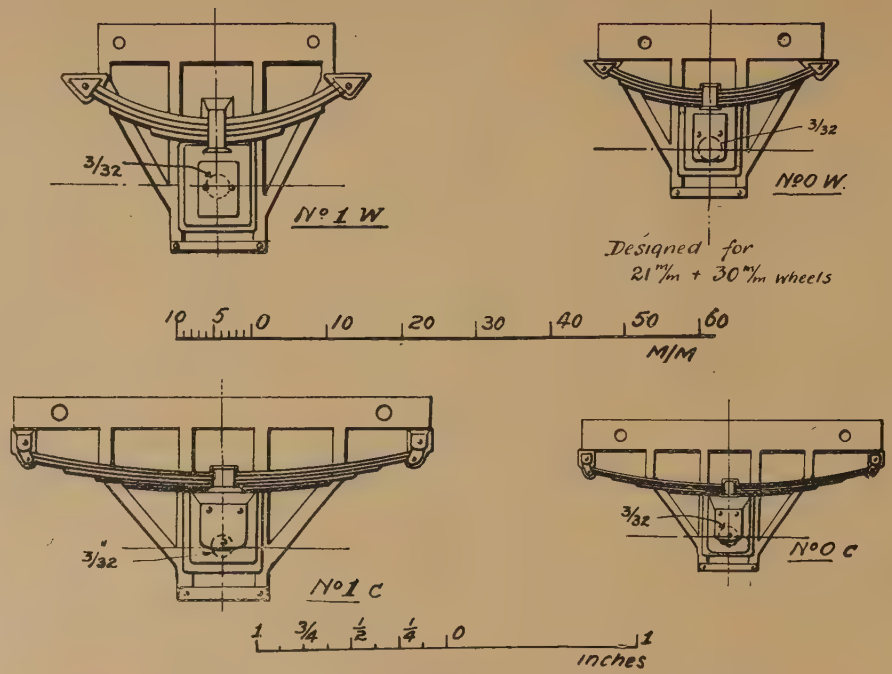


Fig. 380.—Die-cast Axle Guards for Nos. 0- and 1-gauge

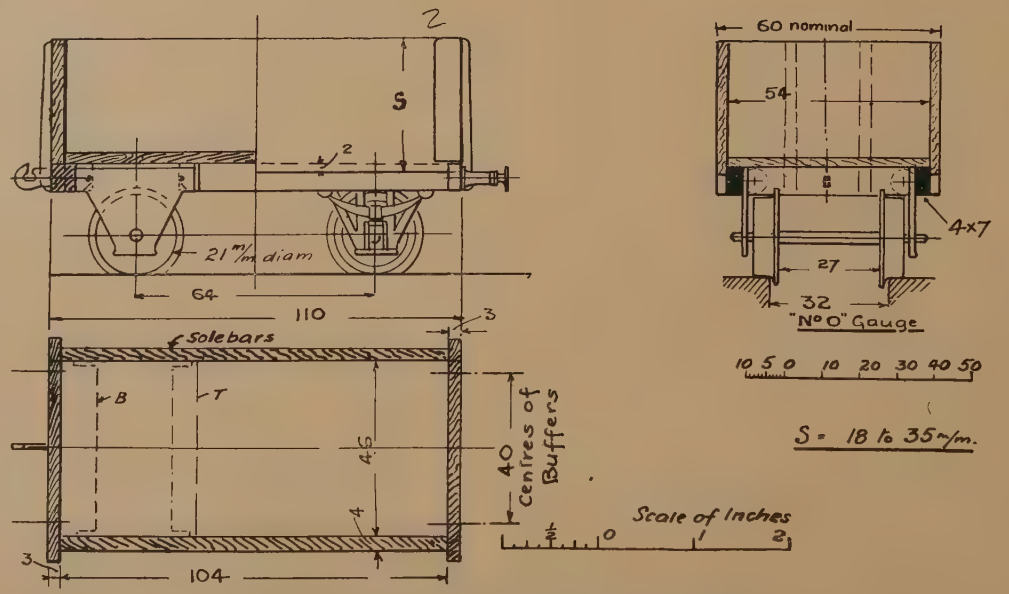


Fig. 381.—General Dimensions of No. 0-gauge Wagon

frame timbers (solebars), and as it is an awkward job to do this with the wheels in place, some makers build up the

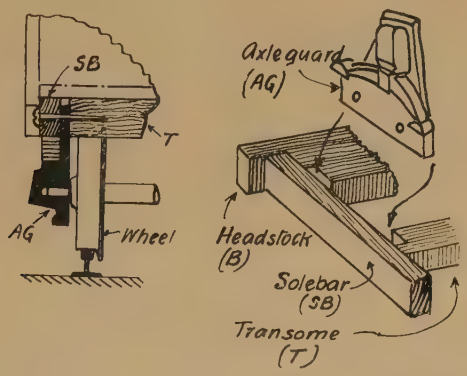


Fig. 382.—A Method of Fixing Axle Guards

body complete and fix the solebars down to the body last, with the wheels and axle guards already assembled.

Fig. 381 gives an idea of the general construction and

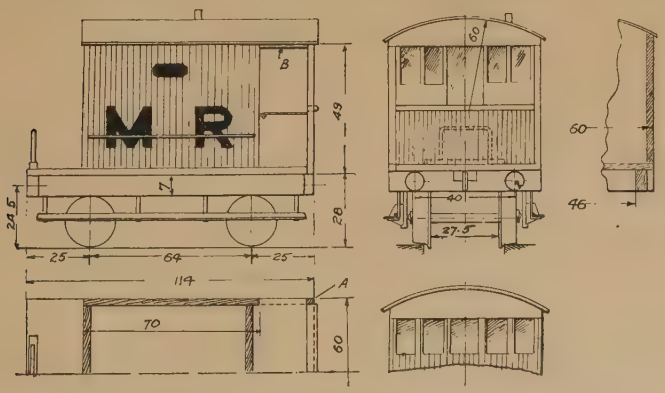


Fig. 383.—Design for 0-gauge M.R. 10-ton Goods Brake Van

proportions of a No. 0-gauge wagon. The underframe, however, can be modified, as shown by the dotted lines,

the buffer planks being extended as at B, and an additional pair of transomes being inserted at T. These are cut so

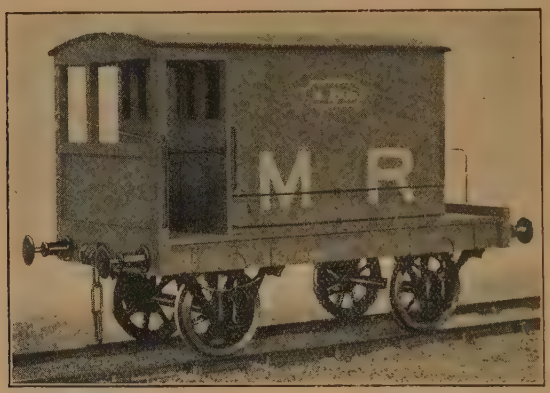


Fig. 384.—Large Model Goods Brake Van

that the flange of the axle guard fits in a sort of a slot. It is secured by seccotine or other cold glue, and when set a screw or a pin can be driven right through the solebar and

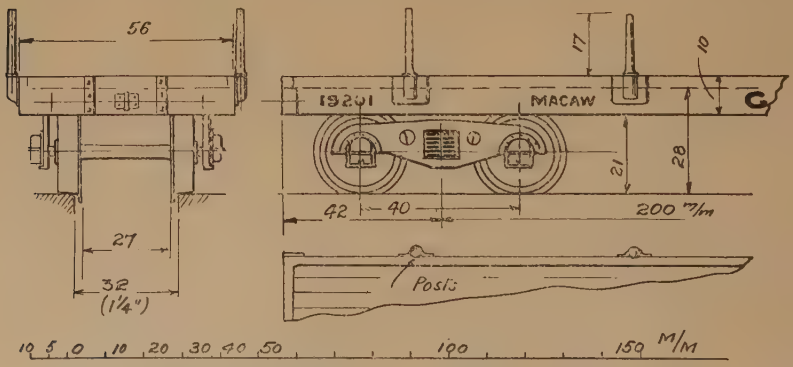


Fig. 385.—Model G.W.R. Bogie Rail Truck

soft white axle guard into the solid wood (B and T) behind it, as shown in the sketch detail Fig. 382.

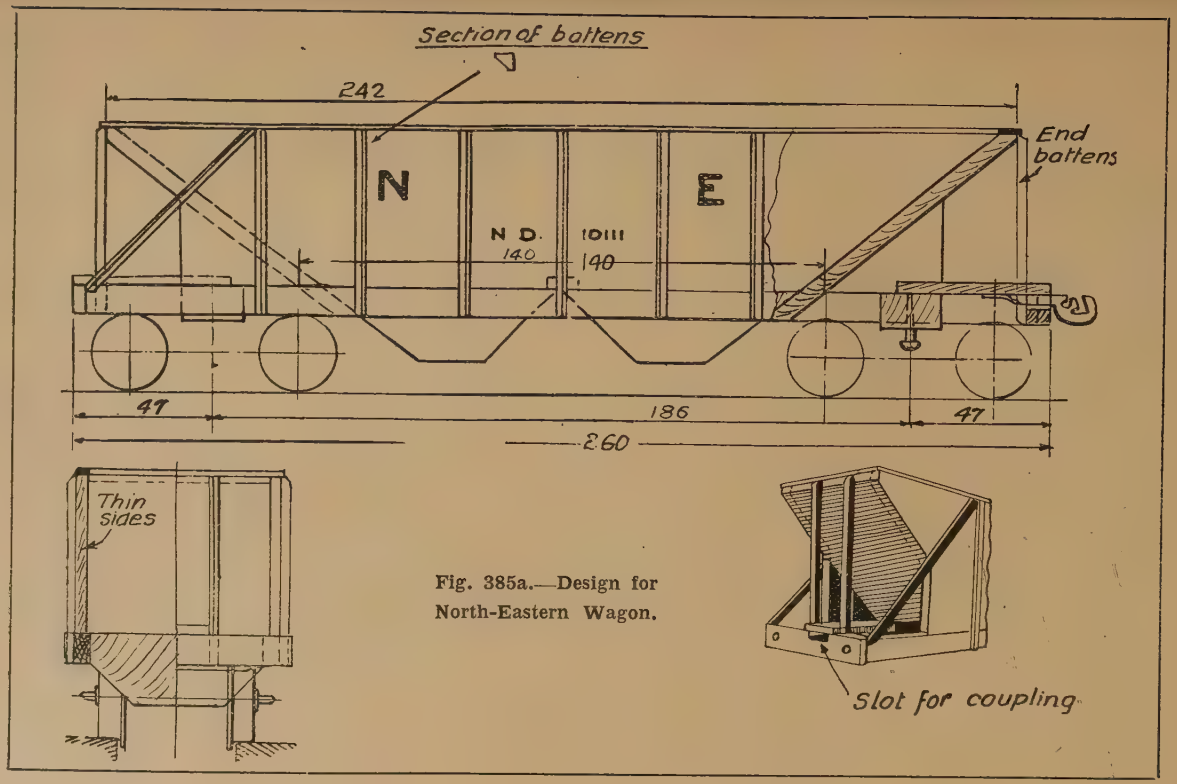


Fig. 385a.—Design for North-Eastern Wagon.

Brake Vans. — Goods brake vans can be made of wagon-stock parts, and a design for a No. 0-gauge vehicle of the Midland (L.M.S.R.) type is reproduced in Fig. 383.

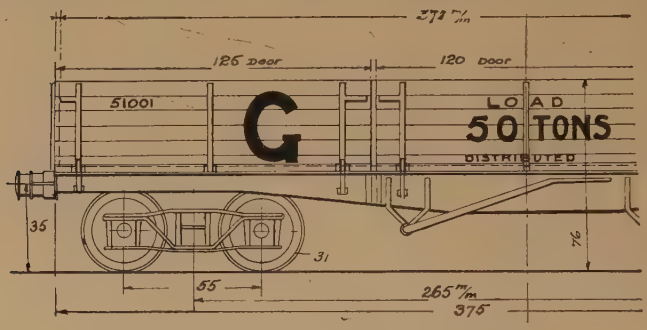


Fig. 386.—Model G.N.R. 50-ton Bogie Wagon

The photograph, Fig. 384, is an illustration of a larger model of the same van using the parts referred to in description of Fig. 377.

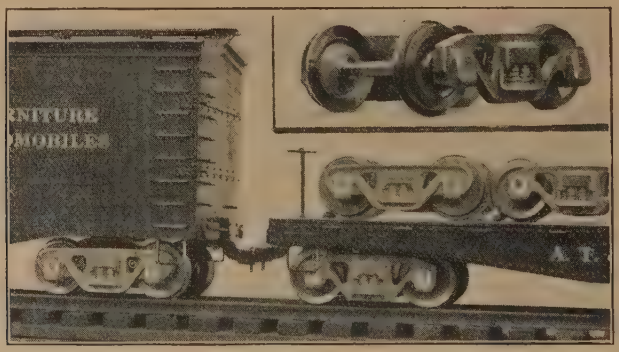


Fig. 387.—Models of Typical American Goods Rolling Stock

Bogie wagons and all special trucks are usually the property of the railway companies. Fig. 385 illustrates a No. 0-gauge model (G.W.R.) rail wagon, made from the

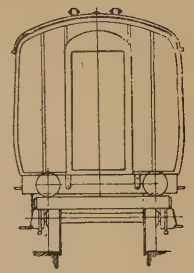


Fig. 388.—Model L.N.W.R. Coach

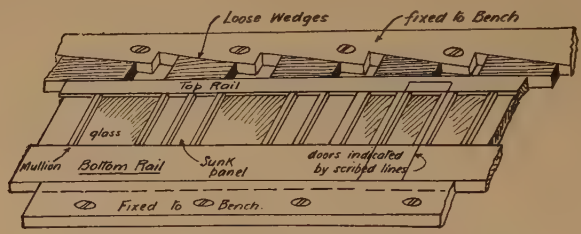


Fig. 390.—Building-up Panel Parts

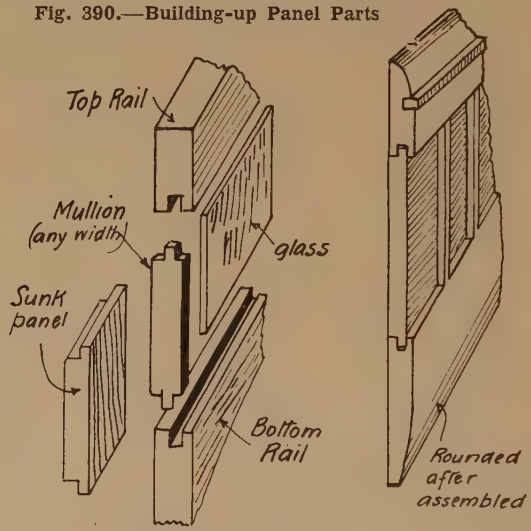


Fig. 389.—Author's System of Model Carriage Construction

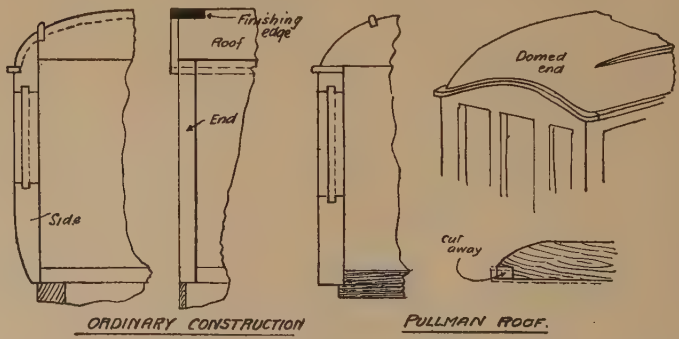


Fig. 391.—Methods of Fitting Roofs

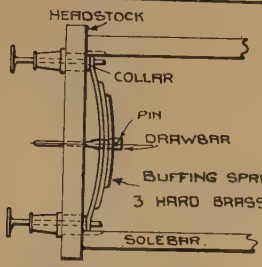


Fig. 392

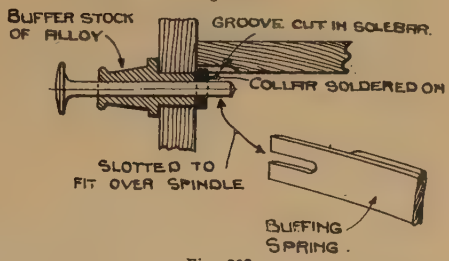


Fig. 393

Figs. 392 and 393.—Laminated Buffer and Drawbar Springs

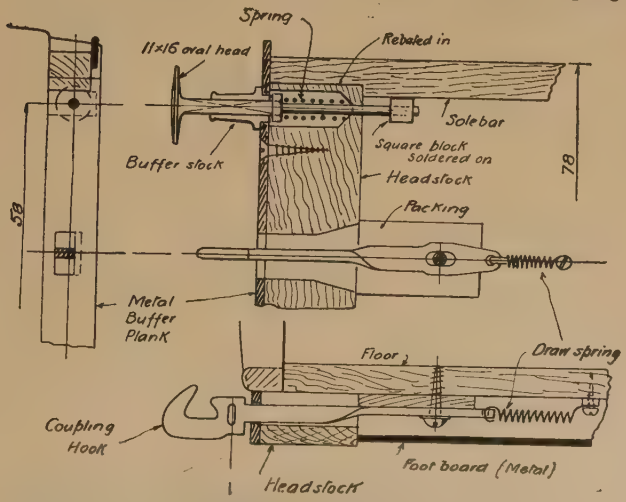


Fig. 394.—Another Method of Arranging Buffing Springs

metal parts of Messrs. Mills Bros., of Sheffield. The high-capacity open wagon, brought out by the G.N.R. (L.N.E.R.),

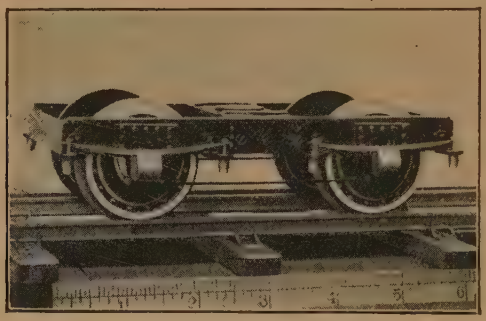


Fig. 395.—Coach Bogie

is shown modelled to a scale of 10 m/m to the foot (No. 1 gauge) in Fig. 386. Models of diamond-frame bogies, as used on this wagon, are standard fitments made by the

Fig. 396.—Model Mail Van

Leeds Model Company, Limited. Typical American vehicles are illustrated by the photographs Fig. 387. All cars and wagons on U.S.A. railroads run on bogies.

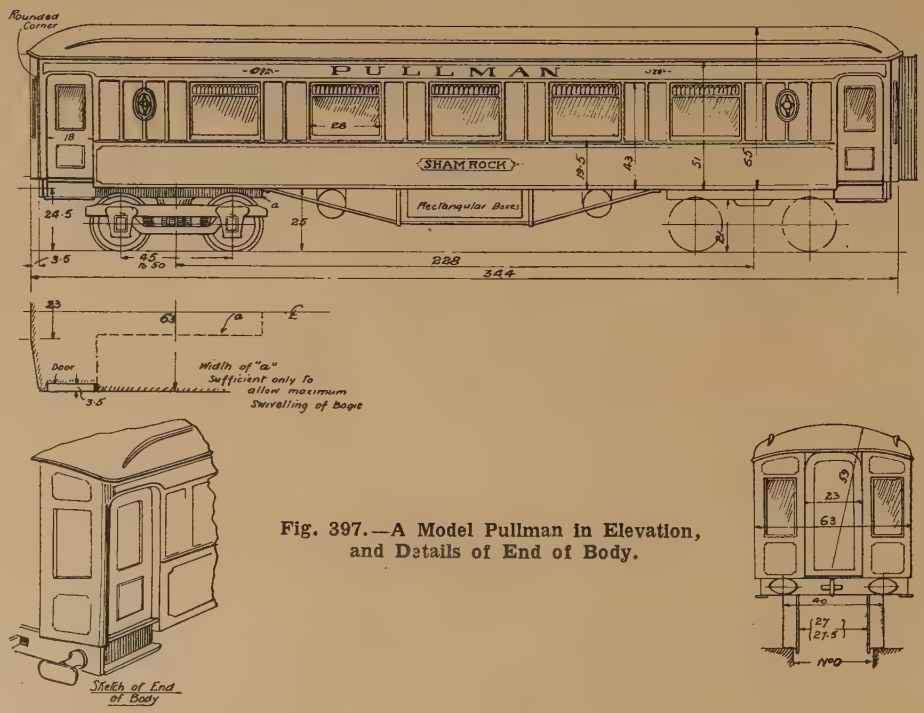


Fig. 397.—A Model Pullman in Elevation, and Details of End of Body.

Model Coaches. — The standard for coaches are slightly different to those of wagons. In model work coaches are made to the scale equivalent of 9 ft. wide, i.e. 63 m/m wide for No. 0-gauge and 90 m/m wide for No. 1-gauge.

Model firms who specialise in the manufacture of model rolling stock get over the difficulties (and cost) of hand finishing by faithfully reproducing the colours and minute details by lithography or transfers. The design, colours

Fig. 398.—A Model Mail Van for a 3½ in. Gauge Railway

and lettering are printed on to tinplate coaches and wagons before the parts are pressed into shape, or in the case of wooden models on to transfers, which are applied to the sides of the vehicle previously painted with flat colour and coated with goldsize.

The amateur, however, usually relies on hand finishing, obtaining transfers only for the lettering and crests. The construction introduced by the writer, in which the sides of the coaches are built up from machined parts, is far

superior to the more obvious method of piercing a strip of thin wood which is to form the coach side, with window openings.

The components of the sides are illustrated in the sketch Fig. 389. The upper and lower rails are grooved, and into these slots fit the glass window- and door-panes and the panels and mullions. The grain of the wood in the two latter runs vertically. Sunk panels are obtained by placing in sequence a mullion-panel piece and then another mullion. The sides are built up on the bench (Fig. 390) in the flat to any desired pattern or arrangement of panels and windows, seccotine or cold glue being used.

Roofs are fitted in two methods, according to the design of the coach. The ordinary design is finished at the ends with a soft metal or steamed wooden strip, as shown in Fig. 391. For Pullman cars the ends of the roofs require to be dome-shaped.

One of the orthodox methods of arranging the buffing and draw-bar springs in coaching and wagon stock is illustrated in Fig. 377. This may be modelled as shown in the sketches Figs. 392 and 393. A simpler construction is illustrated in Fig. 394. Here the buffers are fitted with spiral springs, and the stocks are soldered to a metal buffer plank, which is screwed on to a thick hardwood head-stock. Where oval buffers are used means must be devised to prevent their rotation. The sketch also shows a suitable method of fitting the draw-hook.

Bogies should either be sprung or have equalised side frames. The principles underlying the design of bogies are fully discussed in the companion volumes to this. Fig. 395 illustrates a model L.N.W.R. type bogie made by a skilful amateur, Mr. T. C. Howard, of Northampton.

Among the many interesting examples of coaching stock

that it is possible to reproduce in miniature, the working model mail van is perhaps the most spectacular. The nets can be made to open through levers operated by a ramp placed between or alongside the track. The delivery arm can be made to fly back to the side of the coach when the

Fig. 399.—An Express Slipping a Coach at a Wayside Station

bag is released from the hook by the ground net. The accompanying illustration, Fig. 399, shows an express slipping a coach at a wayside "halt" station, a fascinating diversion for model railway enthusiasts who wish to demonstrate their system.

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